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SECTION I

INTRODUCTION

The purpose of this document is to provide handling qualities investigators with readily usable data on several representative contemporary aircraft. Included are those data required to obtain transfer functions relating the aircraft's response to control inputs. An analytical description of the aircraft's stability augmentor is also given.

For those aircraft for which complete information was available, the following summarizes the contents and presentation:

1. Flight conditions for which computations are made including:
   a. Configurations (e.g., fuel load, flaps, gear, etc.)
   b. Mach/altitude combinations
2. General arrangement
3. Control system description
4. Stability augmentation description
5. Tabulations and/or plots of non-dimensional stability derivatives for trimmed flight
6. Dimensional, mass, and flight condition parameters
7. Dimensional stability derivatives
8. Transfer functions for control inputs
9. Selected handling qualities parameters
10. Data sources

A page number cross index is presented in Table I-1.

The intention has been to make this report completely self-consistent insofar as symbols, nomenclature, definitions, etc. The system used is described in three appendices. Appendix A covers axis systems, symbols and notation, and definitions of nondimensional and dimensional stability derivatives. Appendix B gives the axis system transformations for the derivatives. Appendix C includes the aircraft equations of motion and transfer functions used herein.

TABLE I-1

PAGE NUMBER CROSS INDEX

	NT-33A	F-104A	F-4C	X-15	HL-10	Jetstar	CV-880M	B-747	C-5A	XB-70A
BACKGROUND	6	33	62	109	138	167	194	211	244	274
FLIGHT CONDITIONS	7	34	63	110	139	168	195	212	245	275
GENERAL ARRANGEMENT	8	35	64	111	140	169	196	213	246	276
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TRIMMED NON-DIMENSIONAL DERIVATIVES	10	37	70	114	143	171	198	216	248	279
DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS	22	49	82	125	152	183	200	229	261	292
LONGITUDINAL DIMENSIONAL DERIVATIVES	23	50	83	126	153	184	201	230	262	293
LONGITUDINAL TRANSFER FUNCTION FACTORS										
• SAS off										
– Bobweight loop open										
• Pitch axis control	24	51	84	127	154	185	202	231	263	294
• Thrust	25	52	85	-	-	186	203	232	264	295
– Bobweight loop closed										
• Pitch axis control	-	53	86	-	-	-	-	-	265	296
• Thrust	-	54	88	-	-	-	-	-	266	297
• SAS on										
– Bobweight loop open										
• Pitch axis control	-	-	90	127	155	-	-	-	-	299
• Thrust	-	-	92	-	-	-	-	-	-	301
– Bobweight loop closed										
• Pitch axis control	-	-	94	-	-	-	-	-	-	303
• Thrust	-	-	96	-	-	-	-	-	-	305
LONGITUDINAL HANDLING QUALITIES FACTORS	26	55	98	129	156	187	204	233	267	307
LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES	27	56	99	130	157	188	205	234	268	308
LATERAL-DIRECTIONAL TRANSFER FUNCTION FACTORS										
• SAS off										
– Roll axis control	28	57	100	131	158	189	206	235	269	309
– Yaw axis control	29	58	101	132	159	190	207	236	270	310
• SAS on										
– Roll axis control	-	-	102	133	160	-	-	237	-	311
– Yaw axis control	-	-	104	134	162	-	-	239	-	313
LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS	30	59	106	135	164	191	208	241	271	315
DATA SOURCES	31	60	107	136	165	192	209	242	272	316

The aircraft considered in this report span a wide range of sizes, speeds, and uses. In each case, transfer functions and handling qualities parameters were computed for flight conditions which were selected to cover the flight regimes of interest. A nominal configuration (generally cruise) was picked for all up and away flight conditions. For this nominal configuration, plots of trimmed non-dimensional aerodynamic force and moment coefficients are presented. Also, in most cases, a power approach case is presented along with a tabulation of aerodynamic coefficients. The coefficients are based on rigid wind tunnel data, estimated flexible data, or flight test results, depending upon availability. This is indicated by the words "rigid," "flexible," and "flight" on each aero data plot. Also, the axis system is indicated by "stability" for a body-fixed stability axis system or "body" for a body-fixed axis aligned with the F.R.L. (Further clarification of axis systems used is given in Appendix A.) Descriptions of control systems and stability augmentation systems are given along with transfer functions. Where a longitudinal control system has a significant effect on the equations of motion (as with a bobweight) the stick-free transfer functions and handling qualities are given.

Transfer functions are always given for body axis motion quantities. Handling qualities parameters are also given in the body axis. All acceleration transfer functions (a_z' and a_y') are for the pilot's position. Thrust transfer functions do not include any engine response characteristics.

A substantial portion of this report is in the form of computer printout. The mnemonics used in this printout are defined in Appendix A.

The handling qualities parameters given in this report represent only a small fraction of those developed over the years. The majority presented here are used in past and present versions of MIL-F-8785. Although only SAS-off values are shown, the definitions given in Appendix A are general and could be used in conjunction with the SAS-on transfer functions to yield SAS-on handling qualities parameters.

While complete coverage of each aircraft including only the "latest" and "best" data would be desirable, the major criterion used was that the data be accessible to the author. This is why only isolated flight conditions are given for some aircraft, and also why, as those people more intimately familiar

with each particular aircraft will recognize, the data presented may represent an early estimate in the design process and perhaps the "nominal configuration" is one which never left the drawing board. The data have been reviewed and, although not all those presented indicate unquestionable trends, those data known to be based on only early "guesstimates" or showing unreasonable trends have been deleted. In some cases data were estimated by the author. As to how well the data can be expected to match the flying aircraft, it is assumed that those for whom this document is intended know well the difficulties of obtaining derivatives from flight test data. Every attempt has been made to insure reliable translation, interpretation, and transcription of the data from their source documents.

The manufacturers of the aircraft described herein can not be held accountable for the information presented, nor would they be bound to concur in any conclusions with respect to their aircraft which might be derived from its use.

SECTION II

NT-33A

NT-33A BACKGROUND

"The NT-33A variable stability airplane (Serial No. 51-4120) is an extensively modified T-33 jet trainer. The elevator, aileron and rudder controls in the front cockpit are disconnected from their respective control surfaces and have been connected to separate servomechanisms that make up an 'artificial feel' system. In addition, the elevator, aileron and rudder control surfaces have been connected to individual servos which can be driven by a number of different inputs. These servos receive their electrical inputs from the artificial feel system (pilot's commands, position or force), attitude and rate gyros, accelerometers, dynamic pressure, α vane and β probe. This arrangement, through a response-feedback system, allows the normal T-33 derivatives to be augmented to the extent that the handling qualities of many existing airplanes, future airplanes or hypothetical research configurations, can be simulated. The original T-33 nose section has been replaced with the larger nose of an F-94 to provide the volume required for the electronic components of the response-feedback system and the recording equipment."*

Transfer functions are given for only the primary surfaces and engine thrust although the NT-33A also has other control surfaces and a range of control crossfeed and feedback combinations.

Aerodynamic data, for the most part, was taken from AFFDL-TR-70-71. However, longitudinal data for the high lift configuration was obtained from LAL 127 and Mach number derivatives from NACA-RM-7116.

NT-33A

Nominal Configuration

230 gal Tip Tanks

60% Internal Fuel

W = 13700 lb

c.g. at 0.263 $\bar{c}$, W.L. 100.2

$\left.\begin{array}{l} I_x = 23800 \text{ slug-ft}^2 \\ I_y = 21100 \text{ slug-ft}^2 \\ I_z = 43800 \text{ slug-ft}^2 \\ I_{xz} = 480 \text{ slug-ft}^2 \end{array}\right\}$ Body Axis

Power Approach Configuration

230 gal Tip Tanks

25% Internal Fuel

Full Flaps

Gear Down

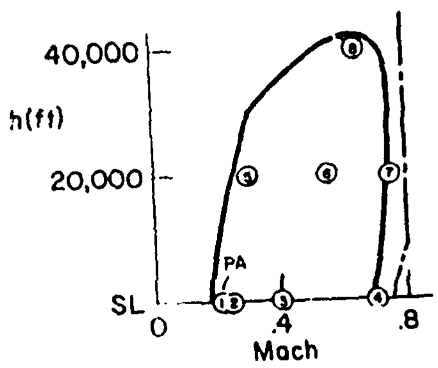
$1.4\ V_s$

W = 11800 lb

c.g. at 0.260 $\bar{c}$, W.L. 100

$\left.\begin{array}{l} I_x = 12700 \text{ slug-ft}^2 \\ I_y = 20700 \text{ slug-ft}^2 \\ I_z = 32000 \text{ slug-ft}^2 \\ I_{xz} = 480 \text{ slug-ft}^2 \end{array}\right\}$ Body Axis

Flight Envelope



——— Level Flight Envelope (Nominal Configuration)

— - — Speed Restrictions

ⓝ Transfer Function Case n

Figure II-1. NT-33A Flight Conditions

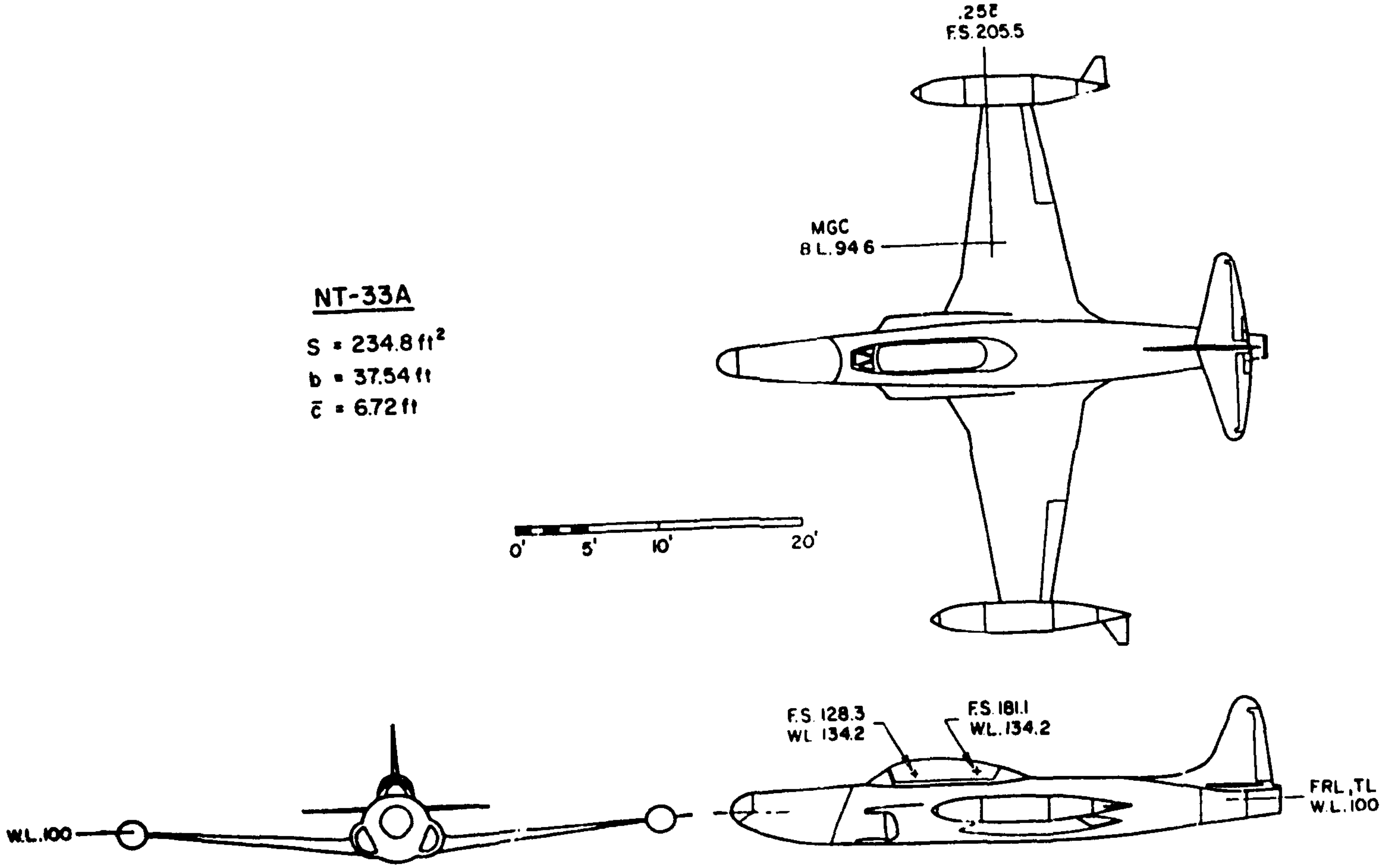


Figure II-2. NT-33 A General Arrangement

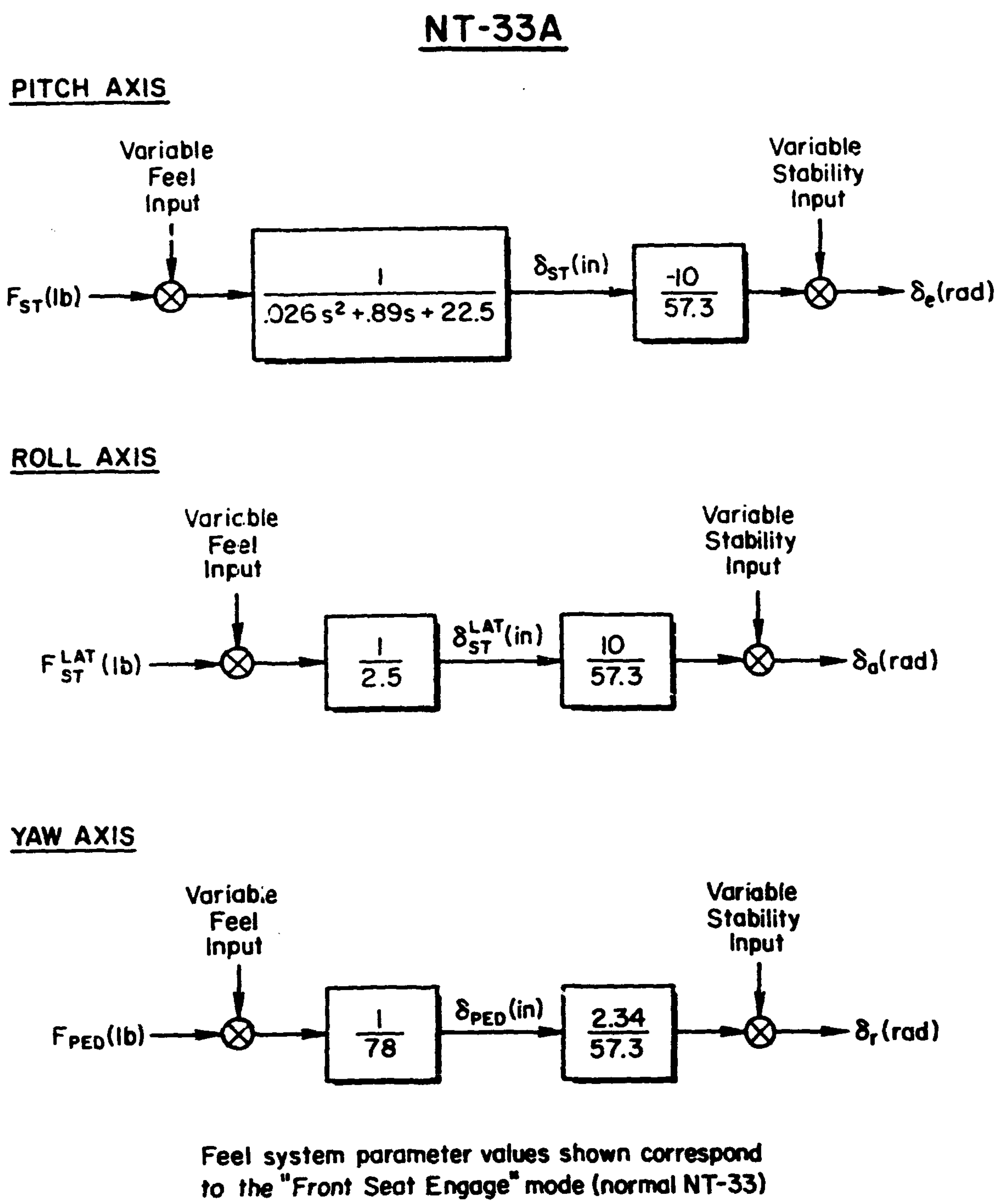


Figure II-3. NT-33A Control System

TABLE II-1

<u>NT-33A</u>

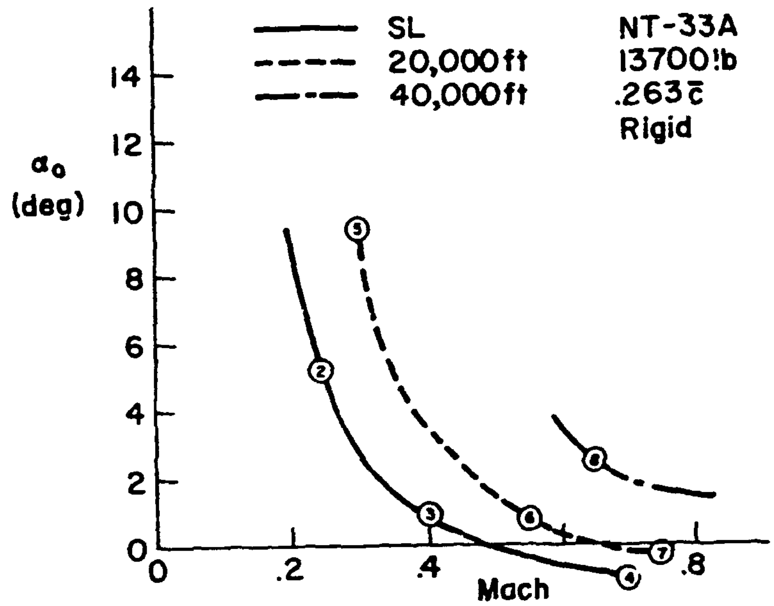
Power Approach Non-Dimensional Stability Derivatives

h = sea level

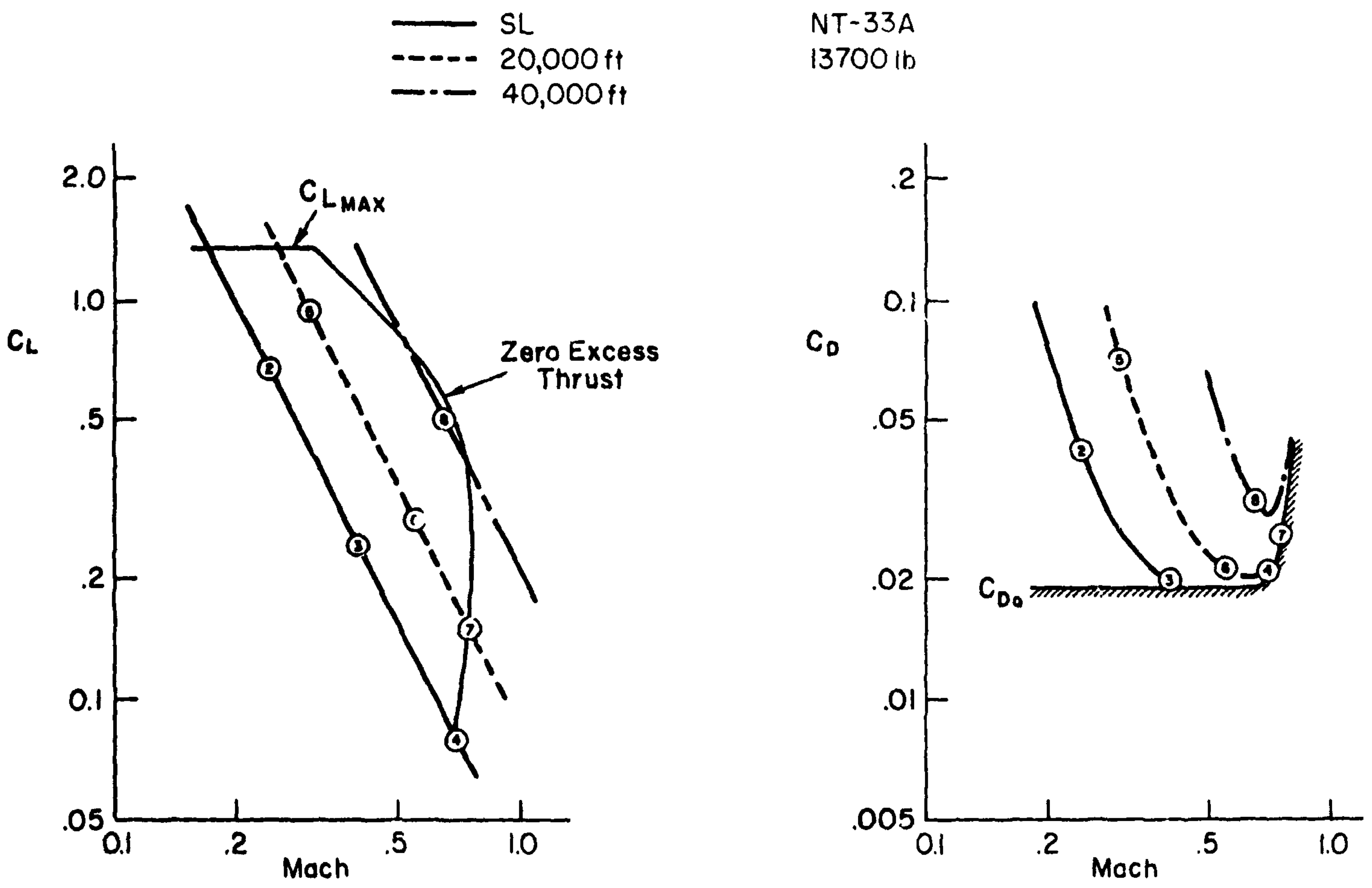
V_{T_o} = 228 ft/sec = 135 kt

α_o = 2.2^o

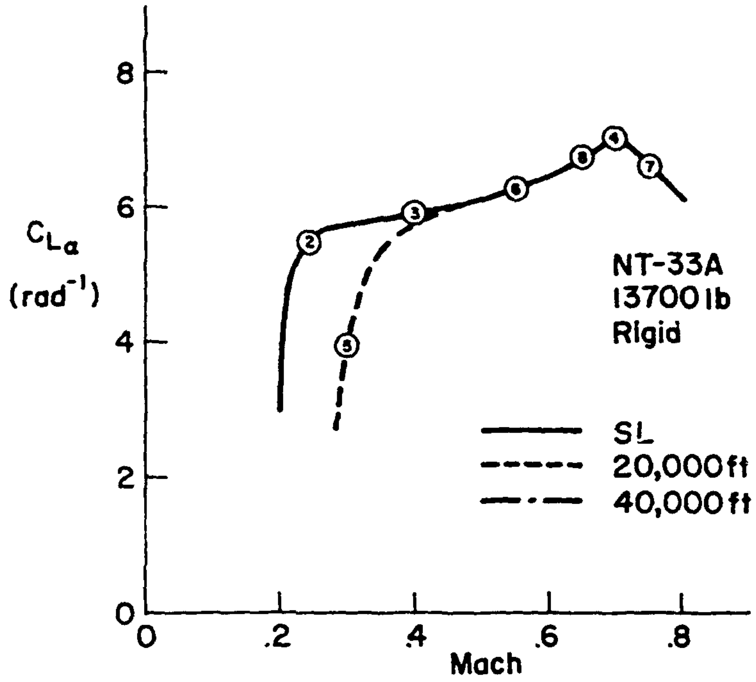
Longitudinal	Lateral-Directional (Stability Axis)
C_L = .813	C_{y_β} = −.72/rad
C_D = .135	C_{n_β} = .049/rad
C_{L_α} = 5.22/rad	C_{ℓ_β} = −.127/rad
C_{D_α} = .54/rad	C_{ℓ_p} = −.57/rad
C_{m_α} = −.401/rad	C_{n_p} = −.045/rad
C_{m_q} = −10/rad	C_{ℓ_r} = .20/rad
$C_{m_{\dot\alpha}}$ = −5/rad	C_{n_r} = −.16/rad
$C_{L_{\delta_e}}$ = .34/rad	$C_{n_{\delta_a}}$ = −.009/rad
$C_{m_{\delta_e}}$ = −.89/rad	$C_{\ell_{\delta_a}}$ = .14/rad
	$C_{y_{\delta_r}}$ = .17/rad
	$C_{n_{\delta_r}}$ = −.073/rad
	$C_{\ell_{\delta_r}}$ = −.002/rad



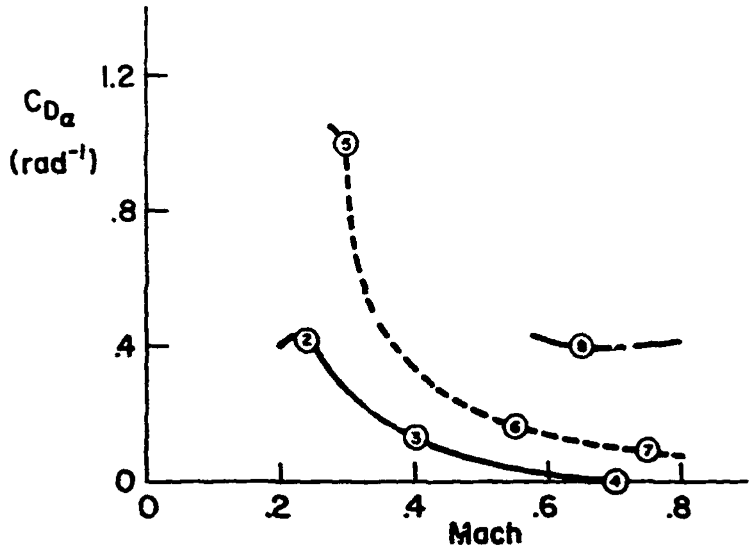
SL
20,000 ft
40,000 ft
NT-33A
13700 lb
.263 $\bar{c}$
Rigid
α_o (deg)
Mach



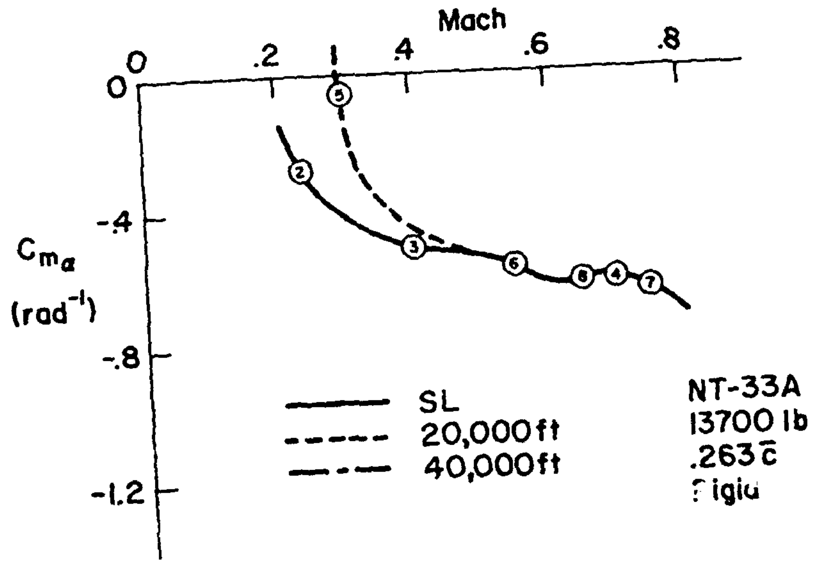
SL
20,000 ft
40,000 ft
NT-33A
13700 lb
C_L
2.0
1.0
.5
.2
0.1
.05
0.1
.2
.5
1.0
Mach
$C_{L_{MAX}}$
Zero Excess Thrust
C_D
.2
0.1
.05
.02
.01
.005
C_{D_0}

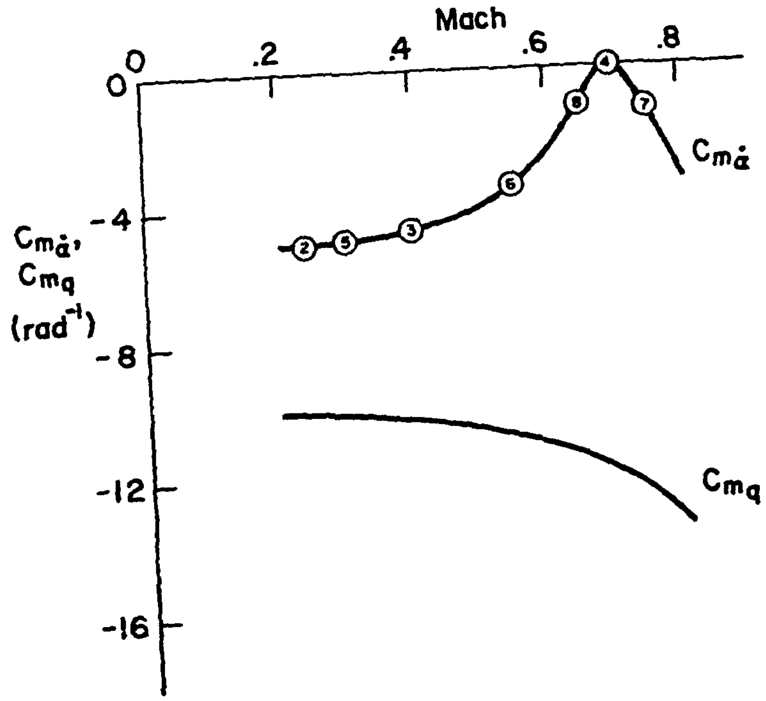


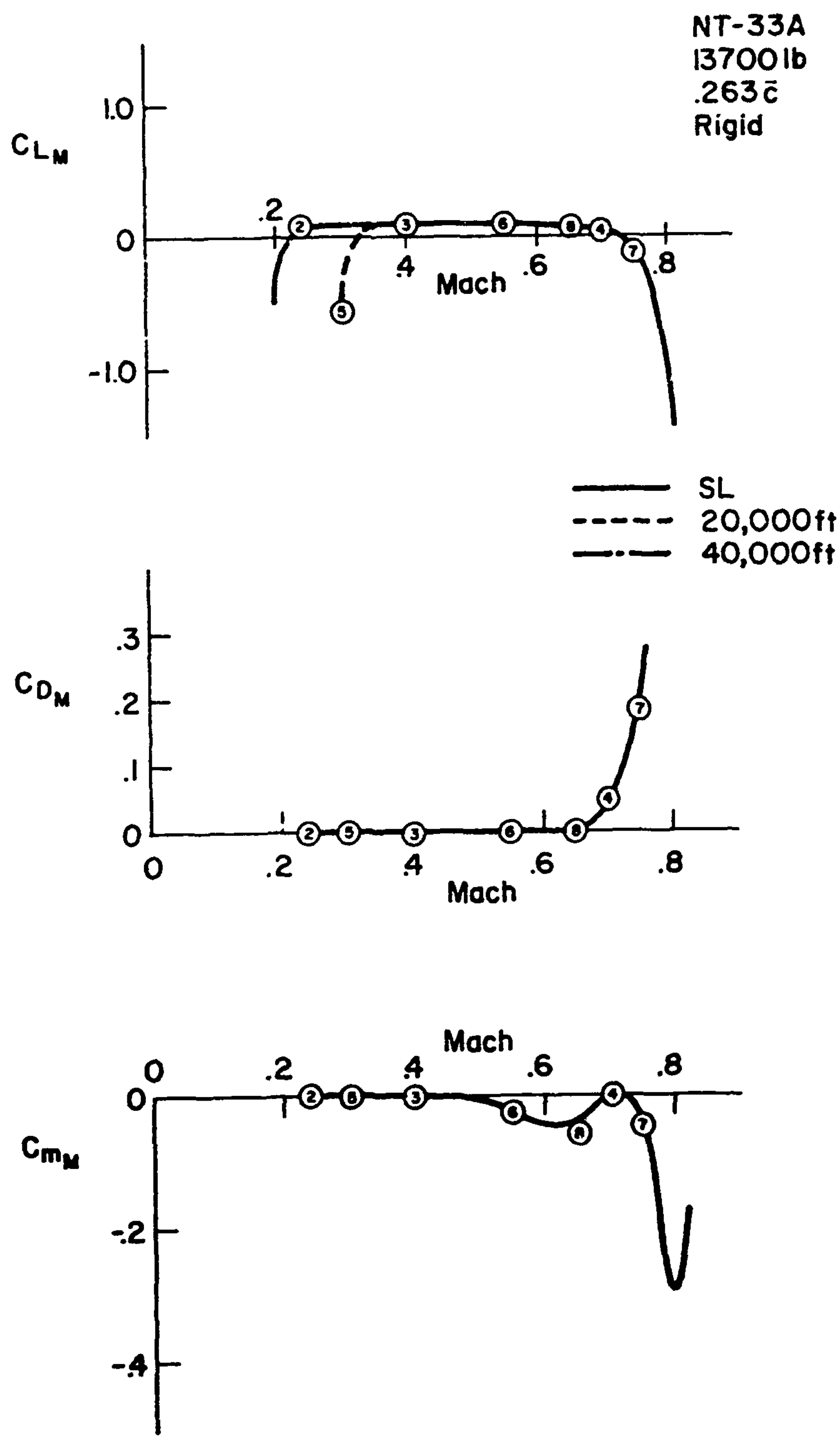
C_{L_α}
(rad^{-1})
NT-33A
13700 lb
Rigid
SL
20,000 ft
40,000 ft
Mach

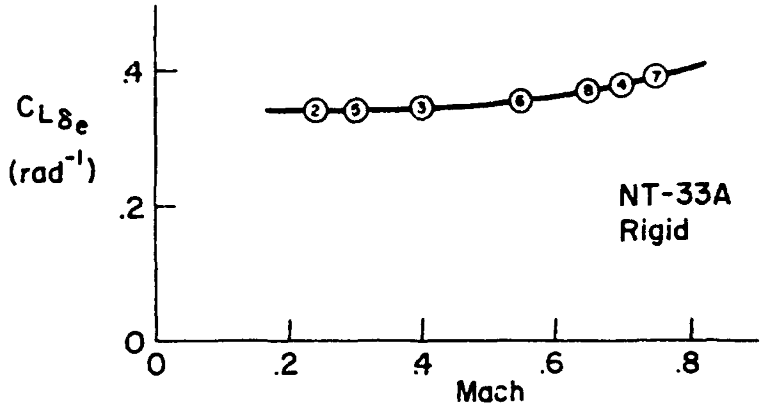


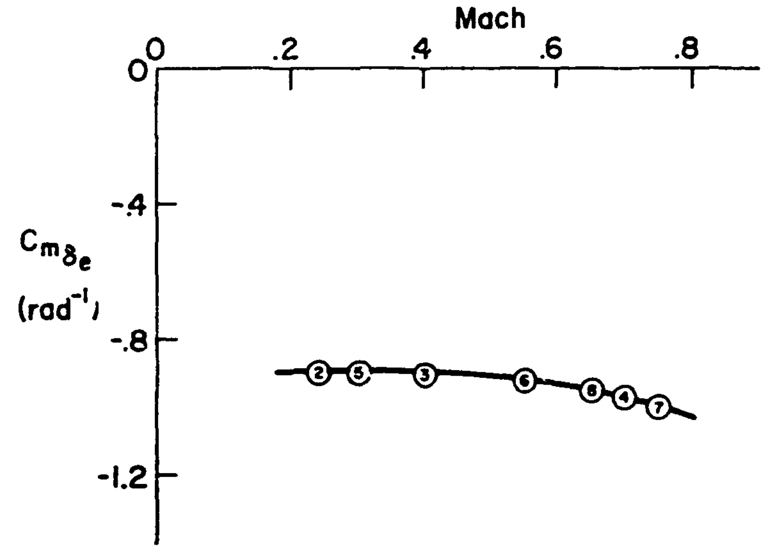
C_{D_α}
(rad^{-1})
Mach

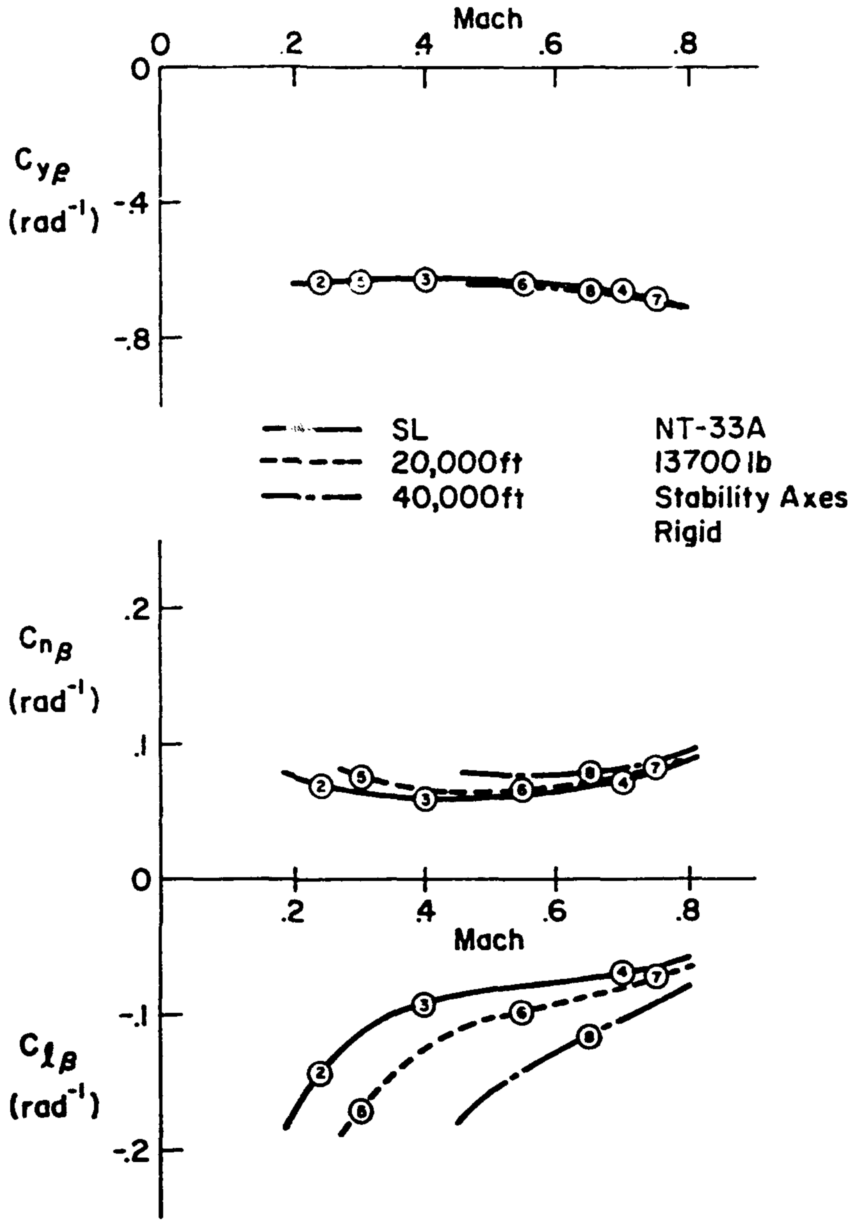

Mach
0
.2
.4
.6
.8
-.4
-.8
-1.2
C_{m_α}
(rad^{-1})
SL
20,000 ft
40,000 ft
NT-33A
13700 lb
.263 $\bar{c}$


Mach
0
.2
.4
.6
.8
-4
-8
-12
-16
$C_{m_{\dot\alpha}}$,
C_{m_q}
(rad^{-1})
$C_{m_{\dot\alpha}}$
C_{m_q}

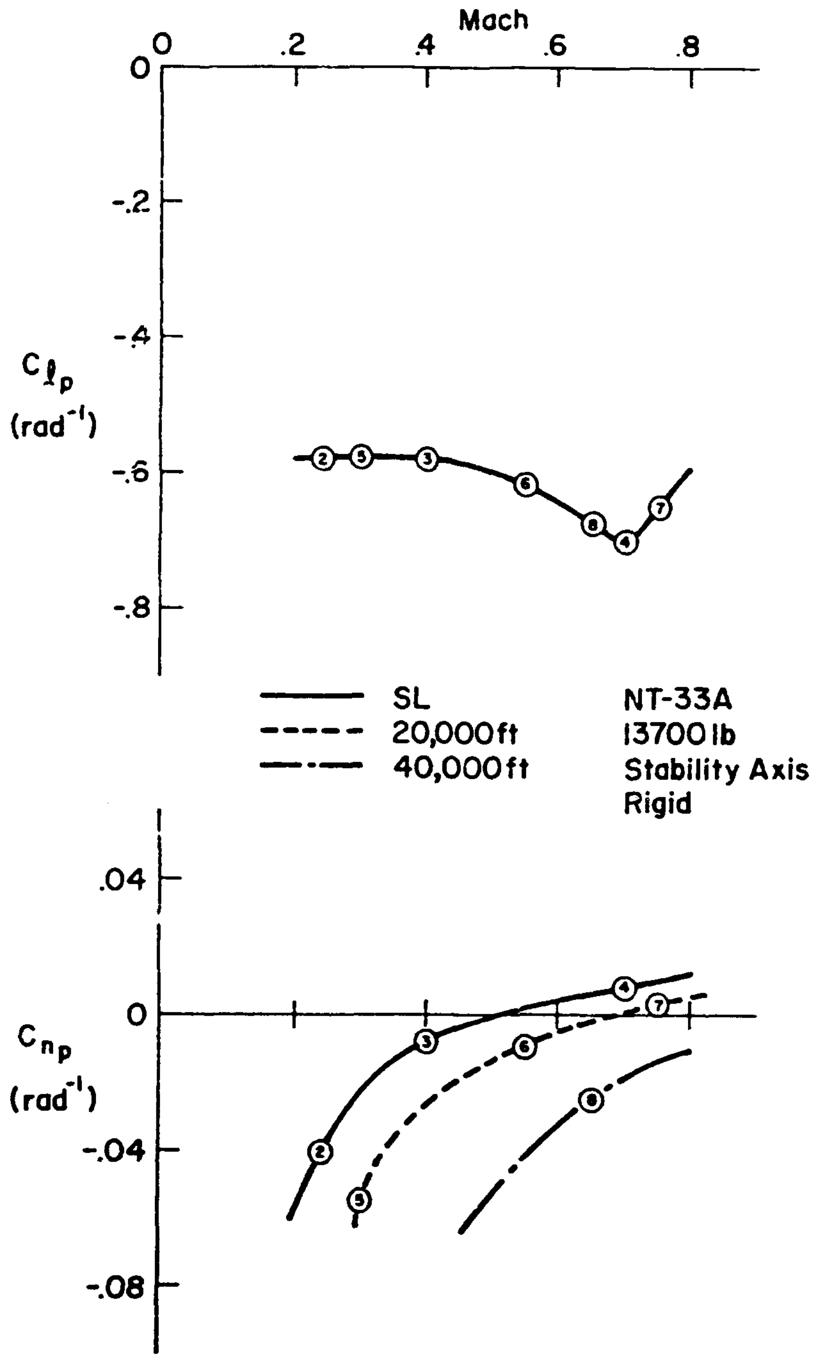

NT-33A
13700 lb
.263 c̄
Rigid
C_{L_M}
1.0
0
-1.0
.2
.4
.6
.8
Mach
SL
20,000ft
40,000ft
C_{D_M}
.3
.2
.1
0
0
.2
.4
.6
.8
Mach
Mach
0
.2
.4
.6
.8
0
C_{m_M}
-.2
-.4

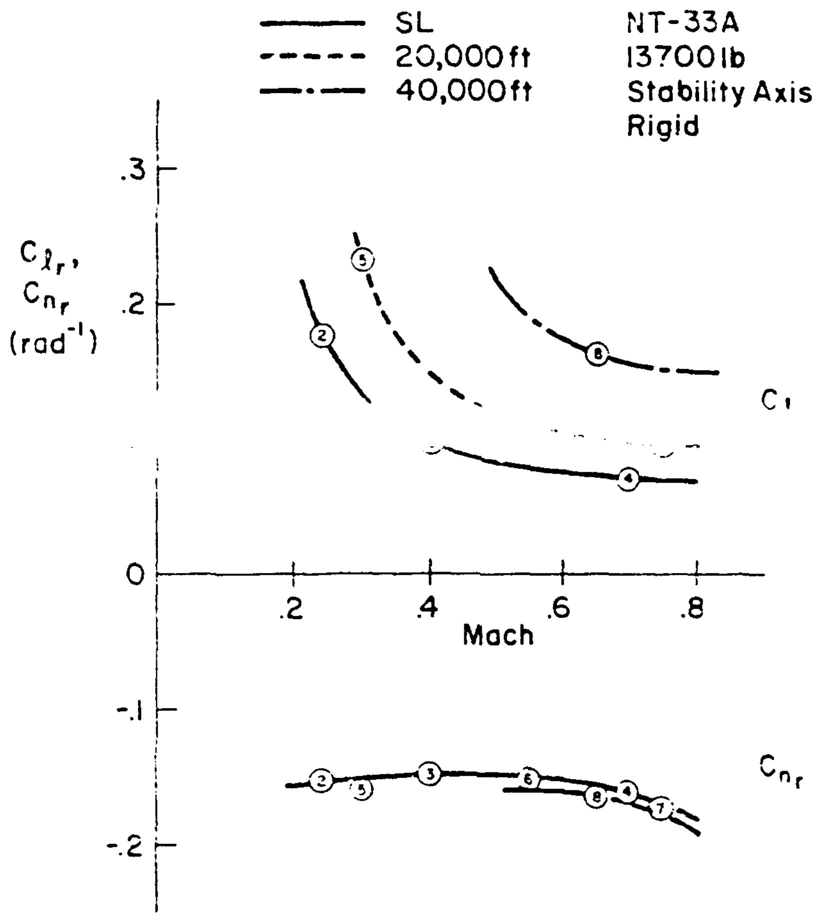

$C_{L\delta_e}$ (rad^{-1})
.4
.2
0
0
.2
.4
.6
.8
Mach
NT-33A
Rigid


Mach
0
.2
.4
.6
.8
0
-.4
$C_{m\delta_e}$ (rad^{-1})
-.8
-1.2

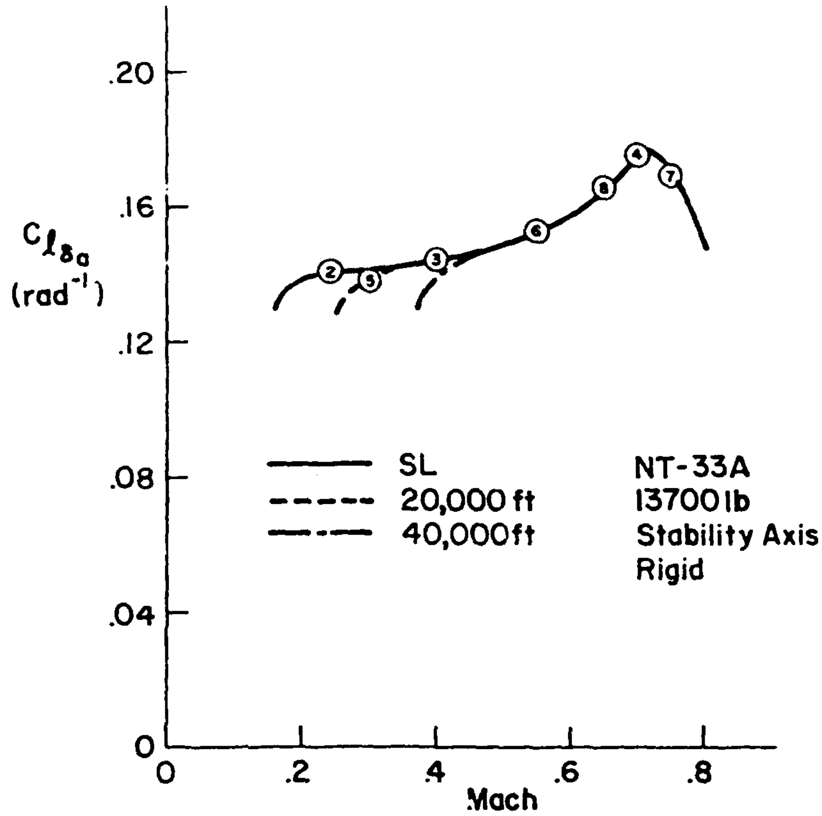


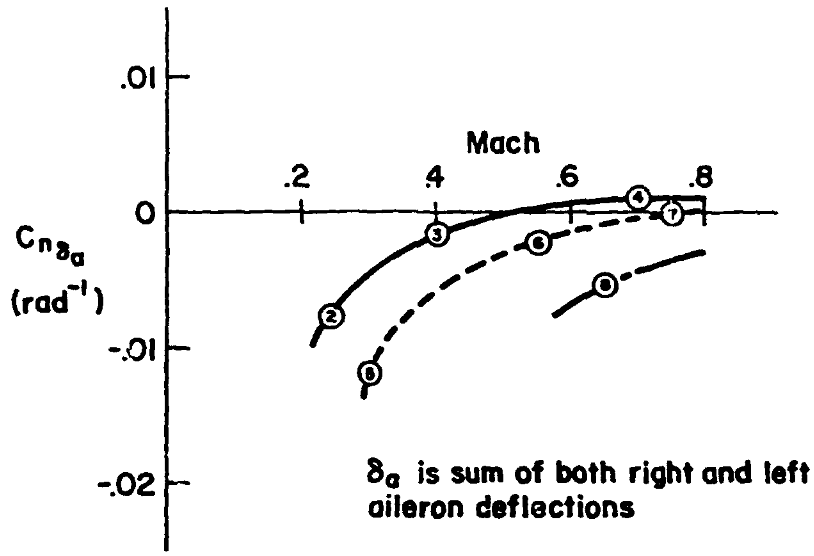
Mach
0
.2
.4
.6
.8
C_{y_β}
(rad^{-1})
0
-.4
-.8
SL
20,000ft
40,000ft
NT-33A
13700 lb
Stability Axes
Rigid
C_{n_β}
(rad^{-1})
.2
.1
0
C_{l_β}
(rad^{-1})
-.1
-.2


Mach
0
.2
.4
.6
.8
0
-.2
-.4
-.6
-.8
C_{ℓ_p}
(rad^{-1})
SL
20,000 ft
40,000 ft
NT-33A
13700 lb
Stability Axis
Rigid
.04
0
-.04
-.08
C_{n_p}
(rad^{-1})



SL
20,000 ft
40,000 ft
NT-33A
13700 lb
Stability Axis
Rigid
C_{ℓ_r},
C_{n_r}
(rad^{-1})
.3
.2
0
-.1
-.2
.2
.4
.6
.8
Mach
C_{ℓ_r}
C_{n_r}


.20
.16
.12
.08
.04
0
$C_{\ell_{\delta_a}}$
(rad^{-1})
0
.2
.4
.6
.8
Mach
SL
20,000 ft
40,000 ft
NT-33A
13700 lb
Stability Axis
Rigid
2
5
3
6
8
4
7


.01
0
-.01
-.02
$C_{n_{\delta_a}}$
(rad^{-1})
Mach
.2
.4
.6
.8
2
3
5
6
4
7
8
δ_a is sum of both right and left aileron deflections

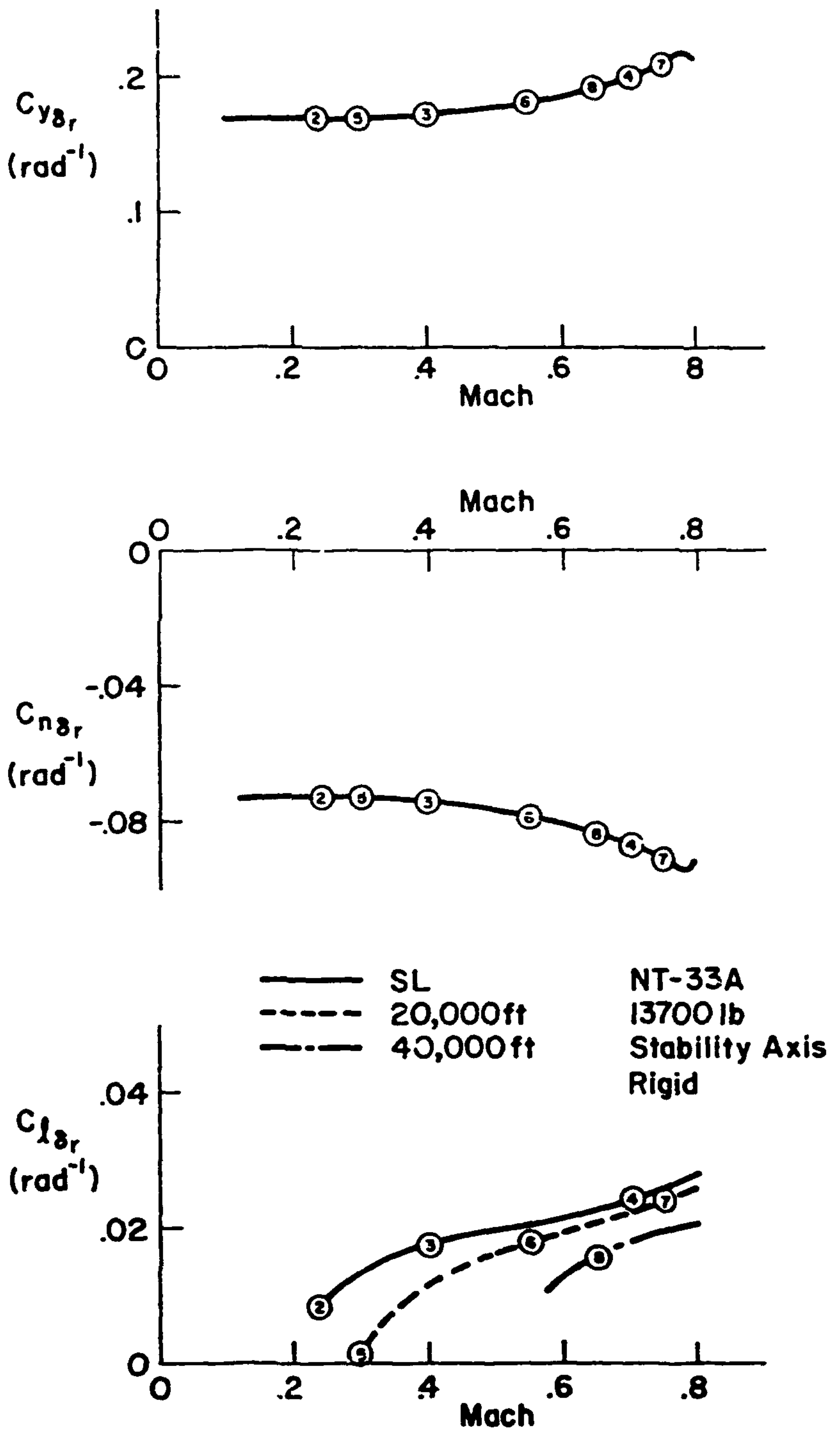

$C_{y_{\delta_r}}$ (rad^{-1})
Mach
$C_{n_{\delta_r}}$ (rad^{-1})
Mach
SL
20,000 ft
40,000 ft
NT-33A
13700 lb
Stability Axis
Rigid
$C_{l_{\delta_r}}$ (rad^{-1})
Mach

TABLE II-2

NT-33A DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

$S = 234.8$ sq ft, $b = 37.54$ ft, $\bar{c} = 6.72$ ft

F/C #	1	2	3	4	5	6	7	8
H(FT)	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M(-)	.204	.242	.400	.700	.300	.550	.750	.650
VTC(FPS)	228.	270.	447.	782.	311.	570.	778.	629.
VTO(KTAS)	135.	160.	265.	463.	184.	338.	461.	373.
VTO(KCAS)	135.	160.	265.	463.	135.	252.	348.	193.
W(LBS)	11800.	13700.	13700.	13700.	13700.	13700.	13700.	13700.
C.G.(MGC)	.260	.263	.263	.263	.263	.263	.263	.263
IX (SLUG-FT SQ)	12700.	23801.	23801.	23801.	23801.	23801.	23801.	23801.
IY (SLUG-FT SQ)	20700.	21101.	21101.	21101.	21101.	21101.	21101.	21101.
IZ (SLUG-FT SQ)	32001.	43802.	43802.	43802.	43802.	43802.	43802.	43802.
IXZ(SLUG-FT SQ)	480.	480.	480.	480.	480.	480.	480.	480.
EPSILON(DEG)	-1.42	-1.37	-1.37	-1.37	-1.37	-1.37	-1.37	-1.37
Q(PSF)	61.7	86.7	237.	726.	61.3	206.	383.	117.
QC(PSF)	62.3	87.9	247.	819.	62.7	222.	440.	129.
ALPHA(DEG)	2.20	5.20	.900	-.900	5.40	.800	-.300	2.50
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	6.51	6.53	6.53	6.53	6.53	6.53	6.53	6.53
LZP(FT)	-2.85	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84
ITH(DEG)	0.	0.	0.	0.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	0.	0.	0.	0.	0.
LTH(FT)	0.	.0200	.0200	.0200	.0200	.0200	.0200	.0200

TABLE II-3

NT-33A LONGITUDINAL DIMENSIONAL DERIVATIVES

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.400	.700	.300	.550	.750	.650
XU *	-.0391	-.00484	-.0104	-.0415	.00477	-.00735	-.0511	-.00355
ZU *	-.248	-.153	-.128	-.162	-.114	-.107	-.0703	-.0766
MU *	.000318	.000603	.000283	-.000760	.000114	-.000183	-.00151	-.000183
XW	.0815	.131	.0562	-.0211	.0657	.0391	.00986	.0391
ZW	-.936	-.991	-1.73	-3.59	-.451	-1.25	-1.80	-.696
MW	-.00827	.00669	-.0206	-.0431	-.000728	-.0157	-.0239	-.00861
ZWD	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-.00152	-.00149	-.00140	0.	-.000785	-.000541	-.000207	-.887E-4
MQ	-.694	-.806	-1.37	-2.80	-.500	-.981	-1.56	-.535
XDE	.516	1.47	.620	-2.65	1.88	.500	-.432	.996
ZDE	-13.4	-16.2	-44.4	-152.	-11.3	-40.9	-82.4	-23.8
MDE	-4.19	-5.83	-16.0	-52.7	-4.13	-14.2	-28.7	-8.28
XDTH	.00273	.00235	.00235	.00235	.00235	.00235	.00235	.00235
ZDTH	0.	0.	0.	0.	0.	0.	0.	0.
MDTH	0.	.948E-6	.948E-6	.948E-6	.948E-6	.948E-6	.948E-6	.948E-6

TABLE II-4

NT-33A ELEVATOR TRANSFER FUNCTION FACTORS

Bare Airframe

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.400	.700	.390	.550	.750	.650
DENOMINATOR								
Z(DET)1	.0948	.0199	.0546	.351	-.00782	.0522	(-.0217)	.0315
W(DET)1	.172	.141	.0933	.0561	.0977	.0678	(.0717)	.0543
Z(DET)2	.622	.680	.548	.484	.887	.398	.380	.268
W(DET)2	1.59	1.62	3.41	6.61	.674	3.19	4.63	2.40
NUMERATORS								
N(U /DE)								
A(U)	.516	1.47	.620	-2.65	1.88	.500	-.432	.996
1/T(U)1	68.0	96.5	177.	2.84	112.	222.	2.15	228.
Z(U)1	.673	.369	.484	(-3.13)	.631	.560	(-6.16)	.545
W(U)1	1.87	1.14	2.80	(249.)	.537	2.23	(280.)	.889
N(W /DE)								
A(W)	-13.4	-16.2	-44.4	-152.	-11.3	-40.9	-82.4	-23.8
1/T(W)1	71.7	97.8	162.	273.	112.	199.	272.	220.
Z(W)1	.115	.0290	.0584	.245	-.0137	.0519	.488	.0373
W(W)1	.186	.135	.0955	.0805	.109	.0774	.0522	.0623
N(THE/DE)								
A(THE)	-4.17	-5.81	-15.9	-52.7	-4.12	-14.2	-28.6	-8.28
1/T(THE)1	.0627	.0258	.0147	.0406	.0123	.0108	.0515	.00794
1/T(THE)2	.890	.955	1.68	3.47	.433	1.20	1.73	.667
N(HD /DE)								
A(HD)	13.4	16.2	44.4	152.	11.5	40.9	82.4	23.8
1/T(HD)1	.0174	-.00440	.00796	.0394	-.0326	.00499	.0501	-.000124
1/T(HD)2	-7.48	-9.06	-15.4	-29.3	-6.54	-14.8	-20.8	-11.8
1/T(HD)3	8.55	10.3	17.4	32.1	7.33	16.1	22.5	12.4
N(AZP/DE)								
A(AZP)	13.7	21.7	59.3	192.	15.5	51.5	105.	30.3
1/T(AZP)1	-.0116	.0145	-.00172	.000680	.00549	-.00134	.000224	.00414
1/T(AZP)2	.0288	-.0191	.00967	.0387	-.0385	.00633	.0499	-.00428
Z(AZP)1	.0507	.0482	.0510	.0734	.0209	.0416	.0454	.0343
W(AZP)1	7.92	8.32	14.2	27.3	5.92	13.7	19.2	10.7

TABLE II-5

NT-33A THRUST TRANSFER FUNCTION FACTORS

Bare Airframe

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.400	.7CC	.300	.550	.750	.650
DENCMINATCR								
Z(DET)1	.09·8	.0199	.0546	.351	-.C0782	.0522	(-.0217)	.0315
W(DET)1	.172	.141	.0933	.0561	.C977	.0678	(.0717)	.0543
Z(DET)2	.622	.680	.548	.484	.887	.398	.380	.268
W(DET)2	1.59	1.62	3.41	6.61	.674	3.19	4.63	2.40
NUMERATCRS								
N(U /DTH)	.00273	.00235	.0C235	.0C235	.00235	.00235	.00235	.00235
A(U)	-.00403	-.0124	-.00284	-.C0057C	-.0214	-.00229	-.000903	-.00366
1/T(U)1	.621	.680	.548	.484	.883	.398	.381	.266
Z(U)1	1.59	1.62	3.41	6.61	.676	3.19	4.63	2.40
W(U)1								
N(W /DTH)	-.000439	-.180E-4	.000143	.000360	.C00116	.000297	.00C570	.000421
A(W)	.00398	.00529	-.C335	-.CC167	-.0415	-.00713	-.000521	-.00815
1/T(W)1	.421	-5.17	-.746	-6.74	-.425	-1.64	-5.23	-.894
1/T(W)2								
N(THE/DTH)	.159E-6	.127E-5	.954E-6	.948E-6	.125E-5	.963E-6	.945E-6	.957E-6
A(THE)	(5.44)	.729	.521	.268	.819	.252	(.899)	.117
Z(THE)1	(7.38)	1.74	2.73	3.26	.506	1.89	(-2.77)	1.15
W(THE)1								
N(HD /DTH)	.000105	.000213	.369E-4	-.369E-4	.C00384	.328E-4	-.123E-4	.000102
A(HD)	7.38	1.96	6.51	-10.9	.242	3.23	-1.24	.849
1/T(HD)1	.379	.612	.727	.795	.817	.816	(7.45)	.365
Z(HD)1	1.37	1.57	3.70	4.42	1.01	4.29	(-16.1)	3.00
W(HD)1								
N(AZP/DTH)	-.104E-5	-.827E-5	-.649E-5	-.619E-5	-.818E-5	-.629E-5	-.617E-5	-.625E-5
A(AZP)	-.00542	-.C107	-.00112	.CC0646	-.C173	-.000790	.000217	-.00224
1/T(AZP)1	663.	43.8	44.6	2.91	.351	36.8	-1.04	26.0
1/T(AZP)2	.389	.633	.685	(8.44)	(1.06)	.730	.768	.701
Z(AZP)1	1.46	1.69	3.38	(51.8)	(32.2)	2.90	16.9	2.20
W(AZP)1								

TABLE II-6

NT-33A LONGITUDINAL HANDLING QUALITIES PARAMETERS

Bare Airframe

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.400	.70C	.300	.550	.710	.650
STICK FIXED								
D(G)/D(U) (DEG/KT)	-.0526	.0131	-.0240	-.118	.0977	-.0150	-.151	.000339
N/A (G/RAD)	6.37	8.05	23.0	83.3	4.26	21.2	41.6	13.1
DE/G (DEG/G)	5.39	3.14	1.75	.565	1.46	1.92	1.02	3.05
CAP (RAD/SEC/SEC/G)	.392	.219	.497	.515	.105	.475	.512	.441
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	908.	--	(32.0)	--
1/C(1/10)	2.17	2.53	1.79	1.51	5.25	1.19	1.12	.758

TABLE II-7

NT-33A LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8
h	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.400	.700	.300	.550	.750	.650
YV	-.125	-.111	-.181	-.338	-.0696	-.128	-.185	-.0674
YB	-28.4	-30.1	-81.0	-264.	-21.6	-72.7	-144.	-42.4
LB'	-5.49	-4.72	-8.02	-18.0	-4.05	-7.42	-9.89	-5.08
NB'	.667	.940	2.71	10.6	.540	2.60	6.24	1.68
LP'	-2.03	-1.32	-2.15	-4.51	-.820	-1.56	-2.23	-.877
NP'	-.116	-.112	-.0512	.0118	-.103	-.0383	-.0141	-.0428
LR'	.641	.305	.320	.495	.214	.256	.328	.179
NR'	-.207	-.173	-.291	-.561	-.104	-.204	-.318	-.110
Y*CA	0.	0.	0.	0.	0.	0.	0.	0.
L'CA	6.01	4.53	12.6	47.0	3.14	11.7	24.0	7.13
N'CA	.0286	.134	.165	.260	.164	.121	.195	.118
Y*CR	.0245	.0301	.0503	.102	.0185	.0363	.0571	.0195
L'CR	-.0125	.443	1.57	5.89	.287	1.39	3.20	.808
N'DR	-1.24	-1.25	-3.50	-12.6	-.883	-3.21	-6.99	-1.92

TABLE II-8

NT-33A AILERON TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.4CC	.7CC	.300	.550	.750	.650
DENOMINATOR								
1/T(DET)1	.0318	.C185	.0143	.C0465	.0129	.00932	00333	.00483
1/T(DET)2	2.20	1.47	2.24	4.57	.966	1.66	2.29	.979
Z(DET)1	.C609	.0435	.103	.127	.C0638	.0647	.0868	.0251
W(DET)1	1.13	1.26	1.75	3.28	1.16	1.70	2.52	1.41
NUMERATORS								
N(B /DA)								
A(B)	.202	.278	.0333	-.999	.351	.0419	-.320	.193
1/T(B)1	.116	.103	.214	-.946	.0616	.144	.330	.0692
1/T(B)2	7.48	3.30	37.8	1.15	1.56	22.6	-3.01	3.05
N(P /DA)								
A(P)	6.01	4.53	12.6	47.C	3.14	11.7	24.0	7.13
1/T(P)1	-.00522	-.0106	-.00111	.000636	-.0169	-.000781	.000215	-.00222
Z(P)1	.200	.145	.141	.136	.116	.102	.0999	.0687
W(P)1	.849	1.05	1.69	3.3C	.868	1.64	2.53	1.33
N(R /DA)								
A(R)	.0286	.134	.165	.260	.164	.121	.195	.118
1/T(R)1	.885	.786	1.75	10.4	.485	1.60	3.86	.828
Z(R)1	(-1.06)	-.673	-.559	-.621	-.450	-.597	-.553	-.482
W(R)1	(-22.0)	2.35	2.98	2.77	1.74	3.02	2.89	2.56
N(PHI/DA)								
A(PHI)	6.01	4.55	12.6	47.C	3.17	11.7	24.0	7.14
Z(PHI)1	.195	.136	.141	.136	.0995	.102	.0999	.0673
W(PHI)1	.848	1.05	1.69	3.3C	.874	1.64	2.53	1.33
N(AYP/DA)								
A(AYP)	17.3	12.7	37.C	135.	9.99	34.0	69.4	21.0
1/T(AYP)1	.122	.110	.204	-.356	.0666	.141	.236	.0730
1/T(AYP)2	-1.24	-1.07	-.806	.481	-.587	-.660	-.395	-.604
Z(AYP)1	.437	.407	.269	.121	.460	.226	.126	.236
W(AYP)1	1.38	1.33	1.89	3.53	1.05	1.77	2.66	1.37

TABLE II-9

NT-33A RUDDER TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.400	.700	.300	.550	.750	.650
DENOMINATOR								
1/T(DET)1	.0318	.0185	.0143	.00469	.0129	.00932	.00333	.00483
1/T(DET)2	2.20	1.47	2.24	4.57	.966	1.66	2.29	.979
Z(DET)1	.0609	.0435	.103	.127	.00638	.0647	.0868	.0251
W(DET)1	1.13	1.26	1.75	3.28	1.16	1.70	2.52	1.41
NUMERATORS								
N(B /DR)								
A(B)	.0255	.0301	.0503	.102	.0185	.0363	.0571	.0195
1/T(B)1	-.0494	-.0312	-.00728	-.00146	-.0377	-.00664	-.00313	-.00955
1/T(B)2	2.05	1.36	2.19	4.57	.836	1.60	2.26	.902
1/T(B)3	42.3	42.9	70.2	122.	49.8	89.2	123.	100.
N(P /DR)								
A(P)	-.0125	.443	1.57	5.89	.287	1.39	3.20	.808
1/T(P)1	-.00533	-.0107	-.00112	.000641	-.0170	-.000785	.000215	-.00223
1/T(P)2	8.06	3.12	3.67	5.07	3.10	3.60	3.74	3.05
1/T(P)3	69.0	-4.00	-4.17	-5.54	-3.83	-4.05	-4.13	-3.42
N(R /DR)								
A(R)	-1.24	-1.25	-3.50	-12.6	-.883	-3.21	-6.99	-1.92
1/T(R)1	2.12	1.35	2.23	4.58	.730	1.66	2.31	.947
Z(R)1	.0159	.0724	.0912	.259	.123	.0170	.0822	-.00220
W(R)1	.605	.620	.469	.343	.737	.463	.355	.486
N(PHI/DR)								
A(PHI)	-.0602	.329	1.51	6.09	.140	1.35	3.23	.724
1/T(PHI)1	(.822)	3.35	3.70	5.06	3.90	3.63	3.74	3.16
1/T(PHI)2	(10.8)	-5.06	-4.30	-5.36	-6.38	-4.15	-4.10	-3.68
N(AYP/DR)								
A(AYP)	-1.40	1.22	4.08	14.8	.799	3.68	7.80	2.03
1/T(AYP)1	-.0683	-.0519	-.0140	-.00362	-.0602	-.0120	-.00564	-.0154
1/T(AYP)2	1.36	.880	1.78	4.37	.471	1.25	2.00	.643
1/T(AYP)3	(.201)	5.29	7.29	11.4	5.13	7.24	9.38	5.98
1/T(AYP)4	(5.68)	-6.80	-9.12	-15.2	-6.23	-8.58	-11.2	-6.90

TABLE II-10

NT-33A LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M	.204	.242	.400	.700	.300	.550	.750	.650
DR PERIOD (SEC)	5.57	4.97	3.61	1.93	5.43	3.71	2.50	4.45
1/C(1/2)	.553	.395	.941	1.16	.0578	.588	.790	.228
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--
P(1)	2.34	2.41	5.18	10.4	2.11	6.29	10.5	5.69
P(2)	.418	1.22	4.79	10.3	.659	6.04	10.3	5.56
P(3)	2.00	2.41	5.16	10.4	2.46	6.61	10.4	6.71
P(2)/P(1)	.179	.505	.924	.983	.313	.961	.981	.977
P(OSC)/P(AV)	.677	.329	.0384	.00752	.552	.0328	.00677	.0542
W(PHI)/W(D)	.751	.829	.966	1.01	.755	.970	1.00	.942
DEL-B-MAX	1.01	.701	.326	.104	.781	.322	.141	.459
PHI TO BETA, PHASE	-297.	-313.	-313.	48.7	-322.	-320.	38.2	-328.
PHI TO BETA	2.14	2.07	1.73	1.06	2.44	1.95	1.22	2.16
PHI TO VE	.539	.438	.223	.0778	.616	.269	.124	.395

NT-33A DATA SOURCES

Hall, G. Warren, and Ronald W. Huber, System Description and Performance Data for the USAF/CAL Variable Stability T-33 Airplane, Air Force Flight Dynamics Laboratory Rept. No. AFFDL TR-70-71, Aug. 1970

Tests of a 1/5 Scale Wind Tunnel Model of the TP-80C Trainer, Lockheed Aerodynamics Laboratory Rept. No. LAL 127, Jan. 23, 1948

Cleary, Joseph W., and Lyle J. Gray, High Speed Wind-Tunnel Tests of a Model Pursuit Airplane and Correlation with Flight-Test Results, NACA-RM-7116, Jan. 21, 1948

Statler, Irving C., et al, The Development and Evaluation of the CAL/Air Force Dynamic Wind Tunnel Testing System; Part I — Description and Dynamic Tests of an F-80 Model, AFFDL-TR-66-153, Feb. 1967

Flight Manual, USAF Series T-33A Aircraft, T. O. 1T-33A-1.

SECTION III

F-104A

F-104A BACKGROUND

The F-104A is a single place, lightweight, supersonic air superiority fighter powered by a single turbojet engine with afterburner. The wing has a full span leading edge flap. Trailing edge flaps have a blowing-type boundary layer control system. Control is provided by conventional ailerons and rudder and an all-movable stabilizer. Pitch, roll, and yaw dampers are incorporated, however their effect is not shown here. Pitch and roll controls are fully irreversible while the yaw control is a cable-actuated rudder without boost. A bobweight is used in the longitudinal feel system. Its position is assumed to be at the pilot's location.

The primary source of data was LR 10794. Drag information was obtained from LR-12873.

The nominal configuration used here is the combat loading for the F-104A based on actual weight and balance data. The PA configuration is a typical loading at flight manual approach speeds.

F-104A

Nominal Configuration

Clean, 750 Rounds Ammunition
50% Internal Fuel
W = 16300 lb
c.g. at .070 $\bar{c}$

$$\left.\begin{array}{l} I_x = 3549 \text{ slug-ft}^2 \\ I_y = 58611 \text{ slug-ft}^2 \\ I_z = 59669 \text{ slug-ft}^2 \\ \epsilon = 2.76^\circ \end{array}\right\} \text{Principal Axis}$$

Power Approach Configuration

Clean
20% Internal Fuel
Full Flaps (45°), BLC
Gear Down
1.4 V_s
W = 14126 lb
c.g. at .164 $\bar{c}$

$$\left.\begin{array}{l} I_x = 3450 \text{ slug-ft}^2 \\ I_y = 55800 \text{ slug-ft}^2 \\ I_z = 56800 \text{ slug-ft}^2 \\ \epsilon = 2.86^\circ \end{array}\right\} \text{Principal Axis}$$

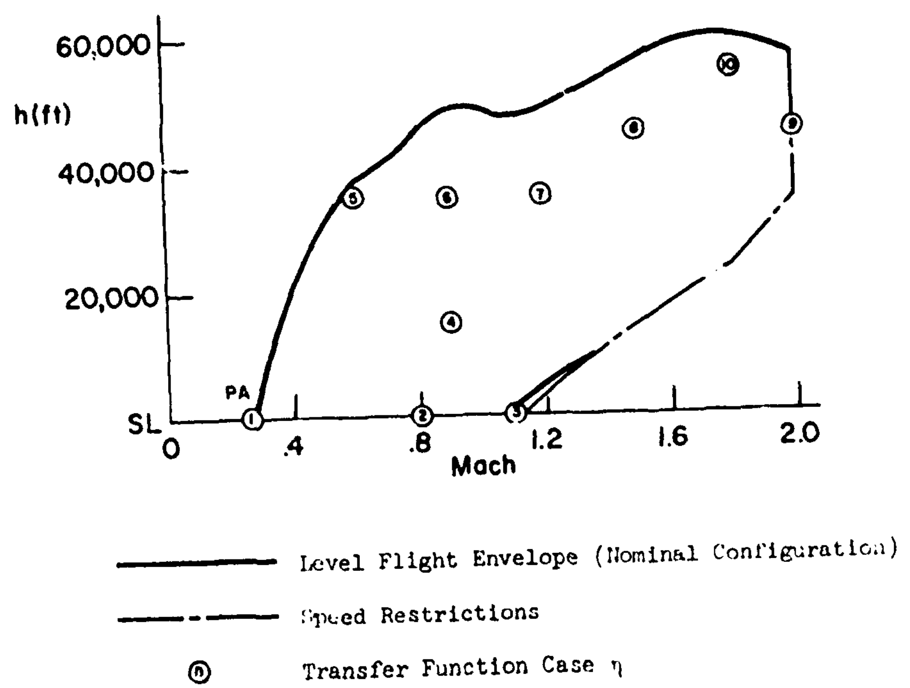


Figure III-1. F-104A Flight Conditions

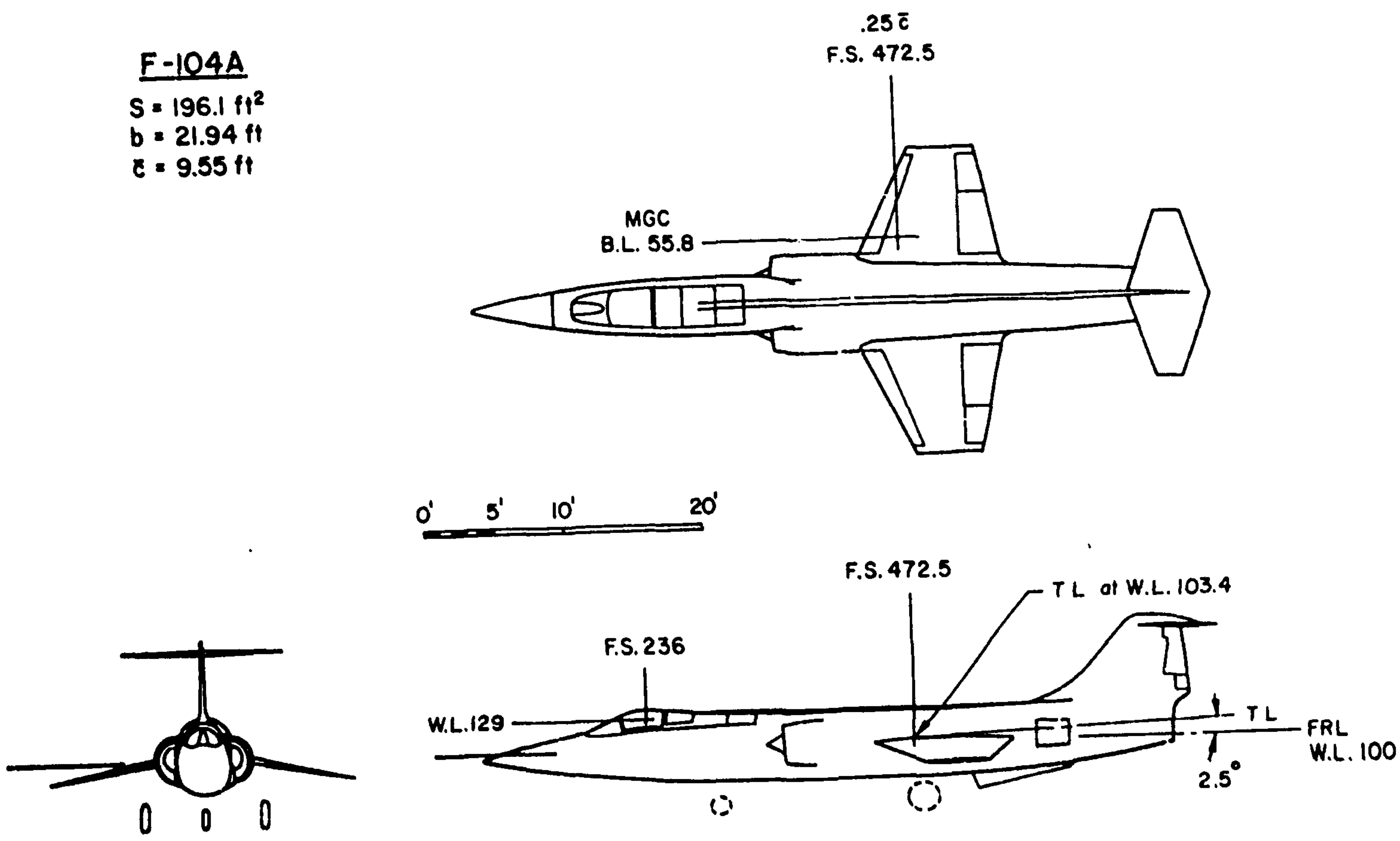


Figure III-2. F-104A General Arrangement

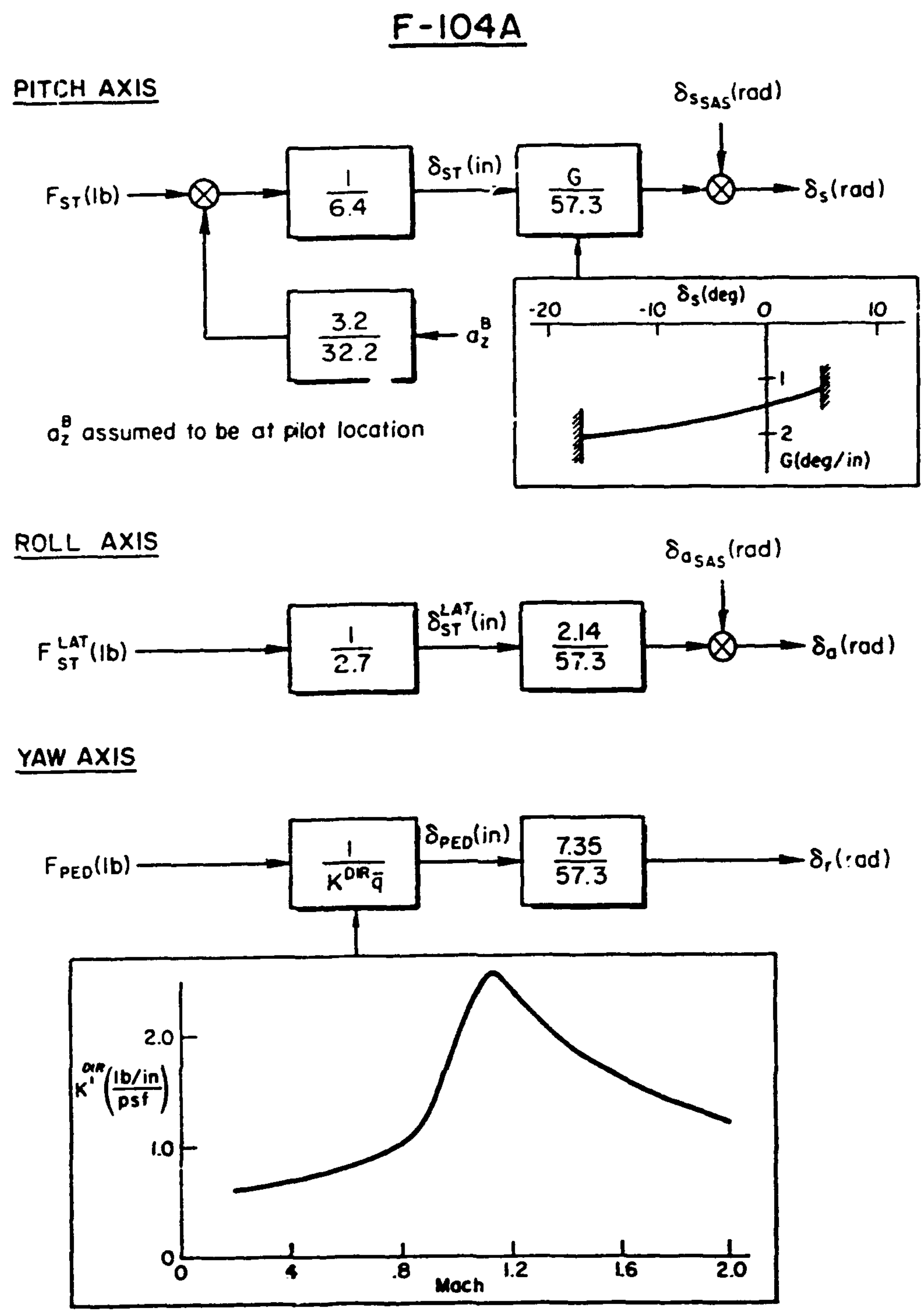


Figure III-3. F-104A Control System

TABLE III-1

F-104A

Power Approach Non-Dimensional Stability Derivatives

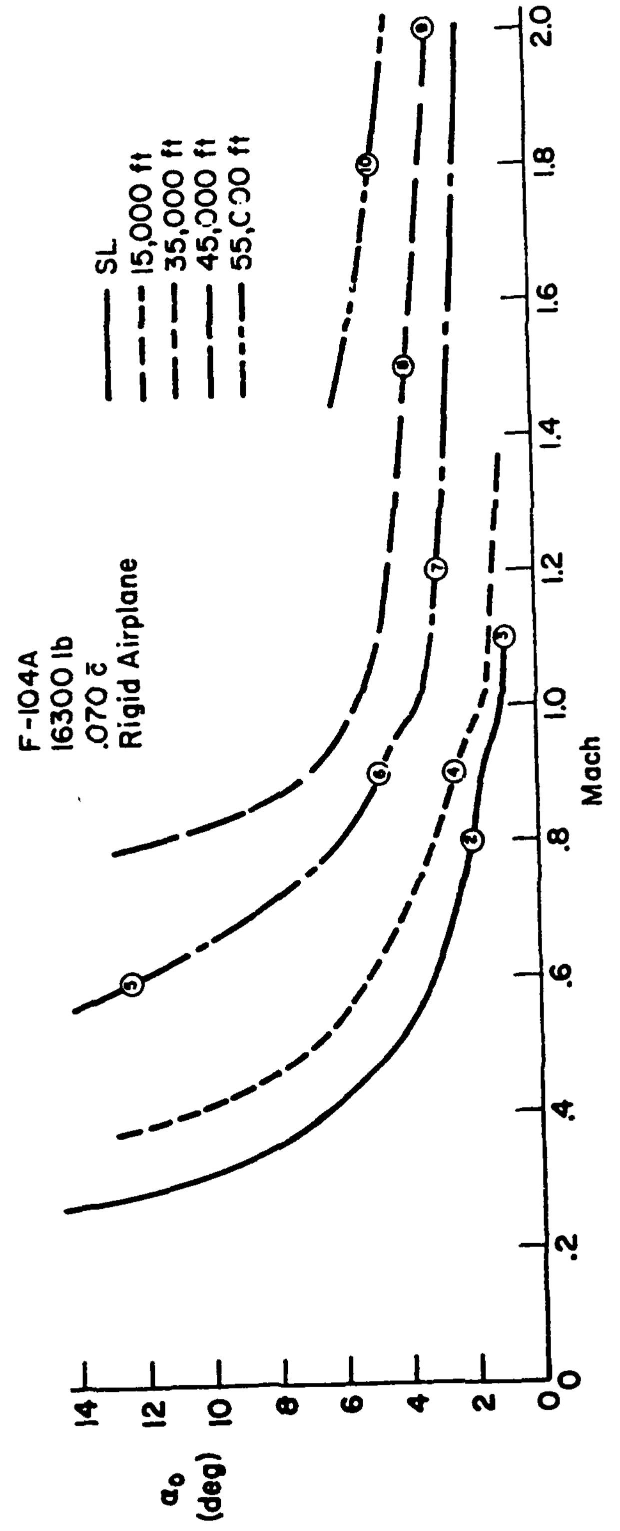
h = sea level

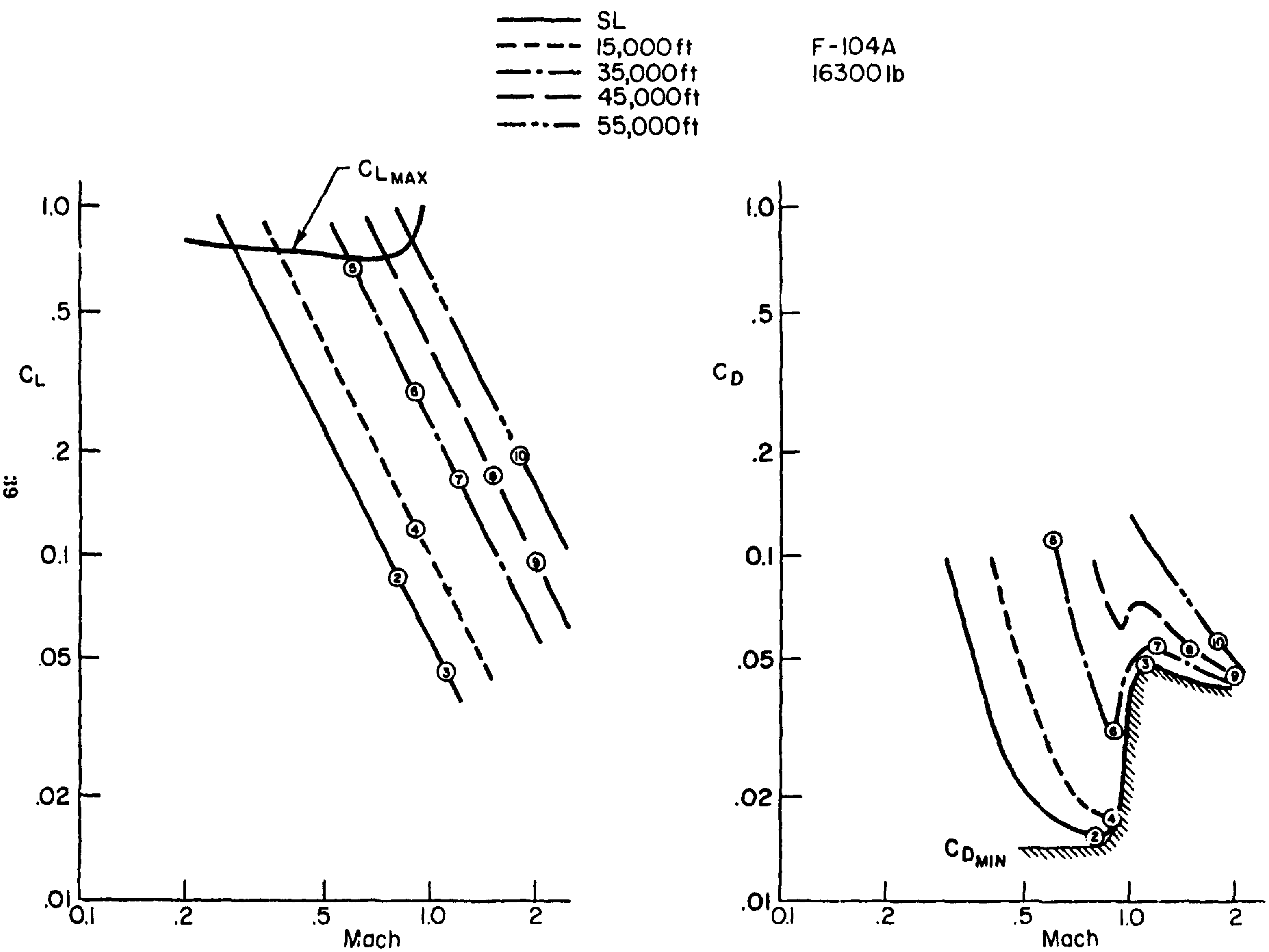
V_{T_o} = 287 ft/sec = 170 kt

α_o = 2.3°

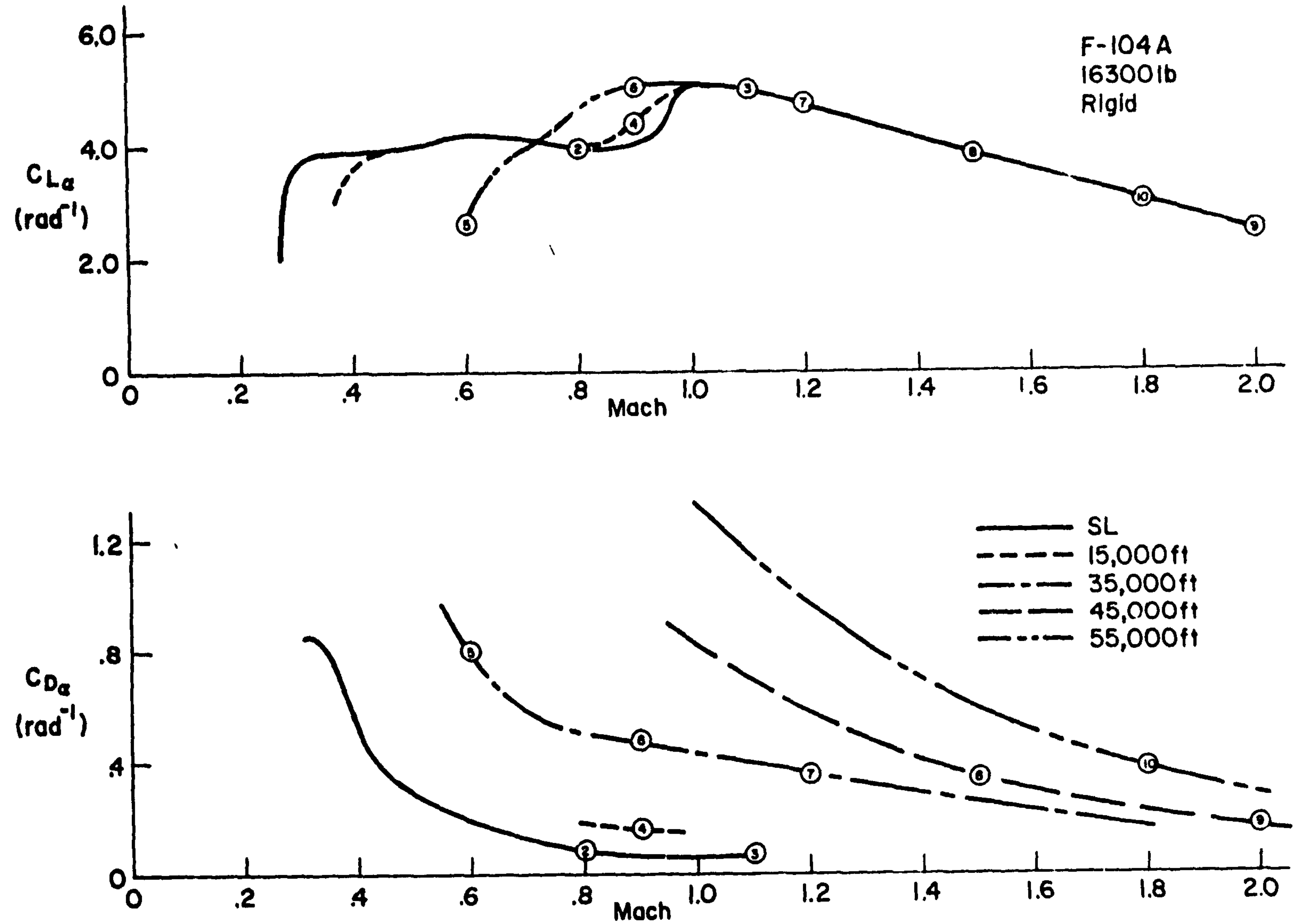
δ_s = −7.1°

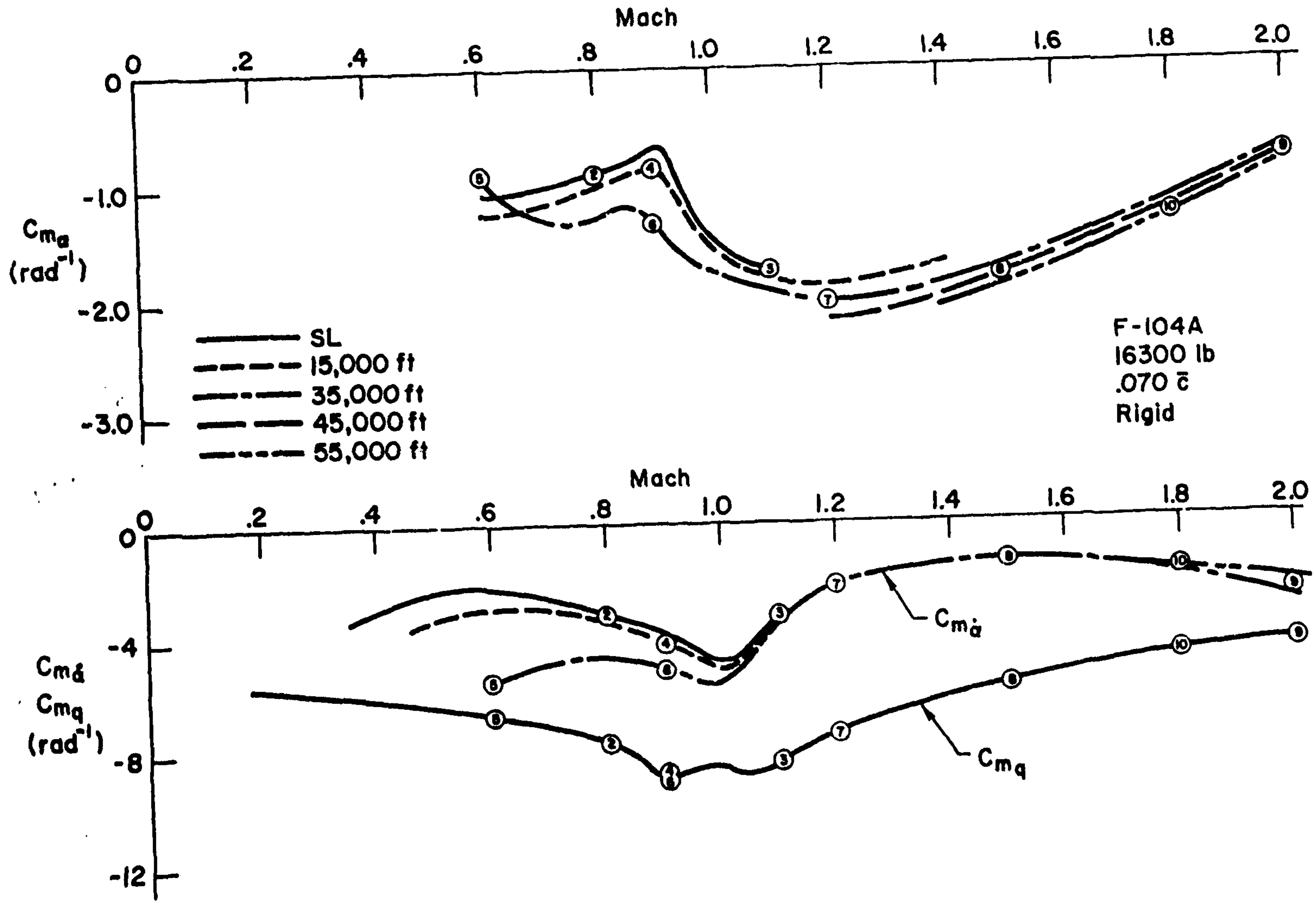
Longitudinal	Lateral-Directional (Stability Axis)
C_L = .735	C_{y_β} = −1.17/rad
C_D = .263	C_{n_β} = .50/rad
C_{L_α} = 3.44/rad	C_{ℓ_β} = −.175/rad
C_{D_α} = .45/rad	C_{ℓ_p} = −.285/rad
C_{m_α} = −.64/rad	C_{n_p} = −.14/rad
$C_{m_{\dot{\alpha}}}$ = −1.6/rad	C_{ℓ_r} = .265/rad
C_{m_q} = −5.8/rad	C_{n_r} = −.75/rad
$C_{L_{\delta_s}}$ = .68/rad	$C_{n_{\delta_a}}$ = .0042/rad
$C_{m_{\delta_s}}$ = −1.46/rad	$C_{\ell_{\delta_a}}$ = .039/rad
	$C_{y_{\delta_r}}$ = .208/rad
	$C_{\ell_{\delta_r}}$ = .045/rad
	$C_{n_{\delta_r}}$ = −.16/rad
	$C_{y_{\delta_d}}$ = .0325/rad
	$C_{n_{\delta_d}}$ = −.025/rad
	$C_{\ell_{\delta_d}}$ = −.0044/rad

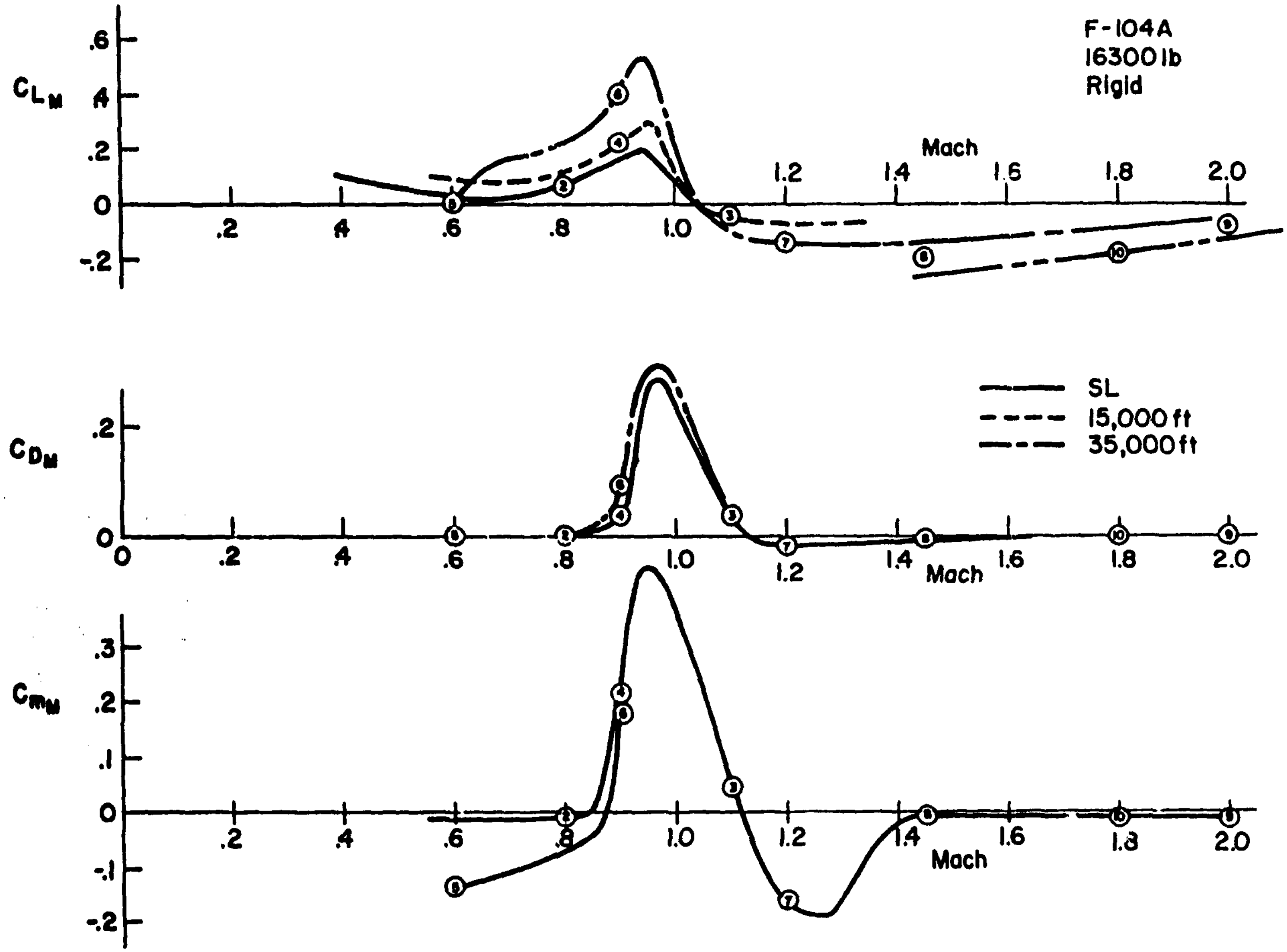

F-104A
16300 lb
.070 c̄
Rigid Airplane
SL
15,000 ft
35,000 ft
45,000 ft
55,000 ft
α_o
(deg)
Mach
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2
4
6
8
10
12
14



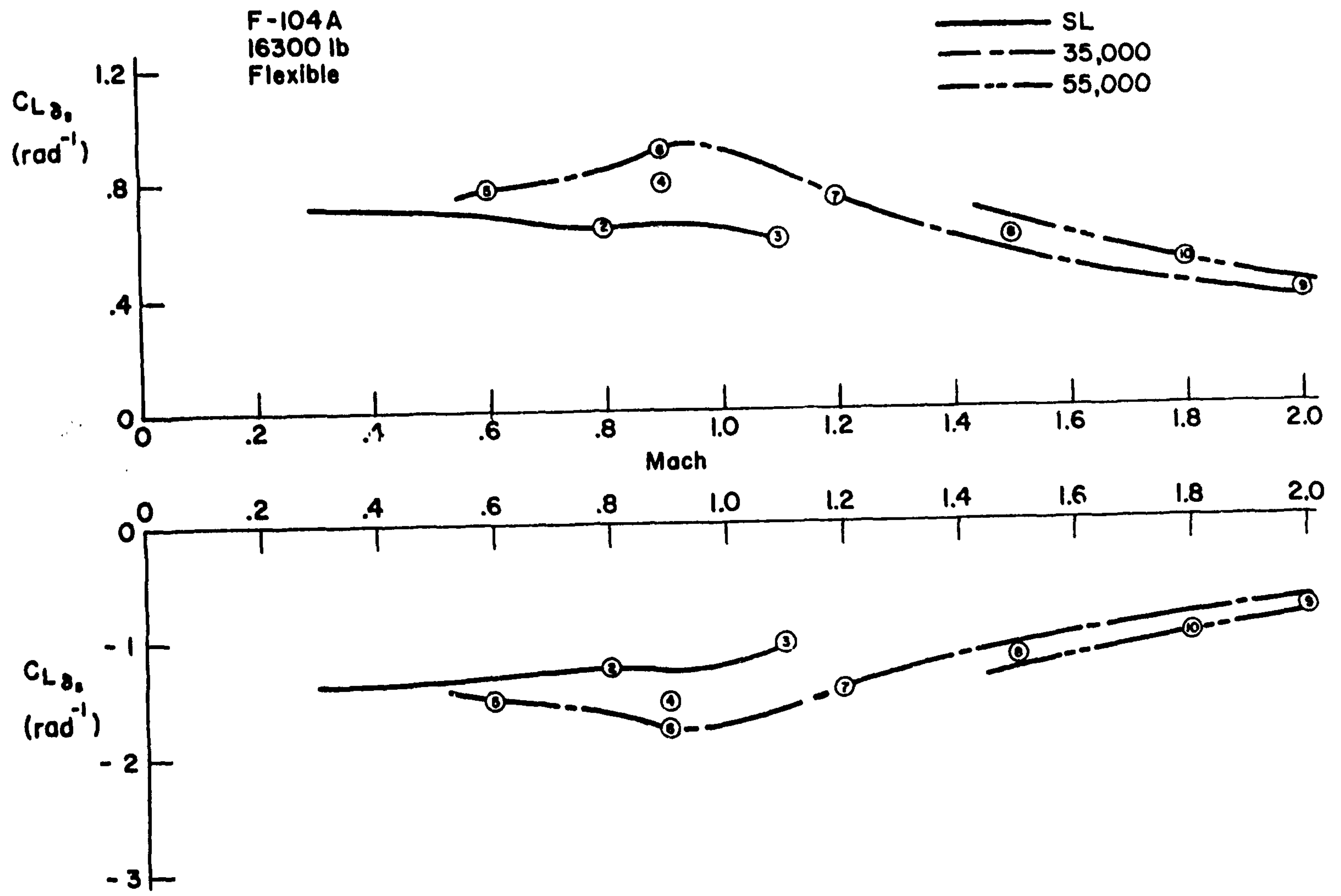
SL
15,000 ft
35,000 ft
45,000 ft
55,000 ft
F-104A
16300 lb
$C_{L_{MAX}}$
C_L
C_D
$C_{D_{MIN}}$
Mach
Mach


F-104A
16300 lb
Rigid
C_{L_α} (rad^{-1})
6.0
4.0
2.0
0
Mach
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
C_{D_α} (rad^{-1})
1.2
.8
.4
SL
15,000ft
35,000ft
45,000ft
55,000ft

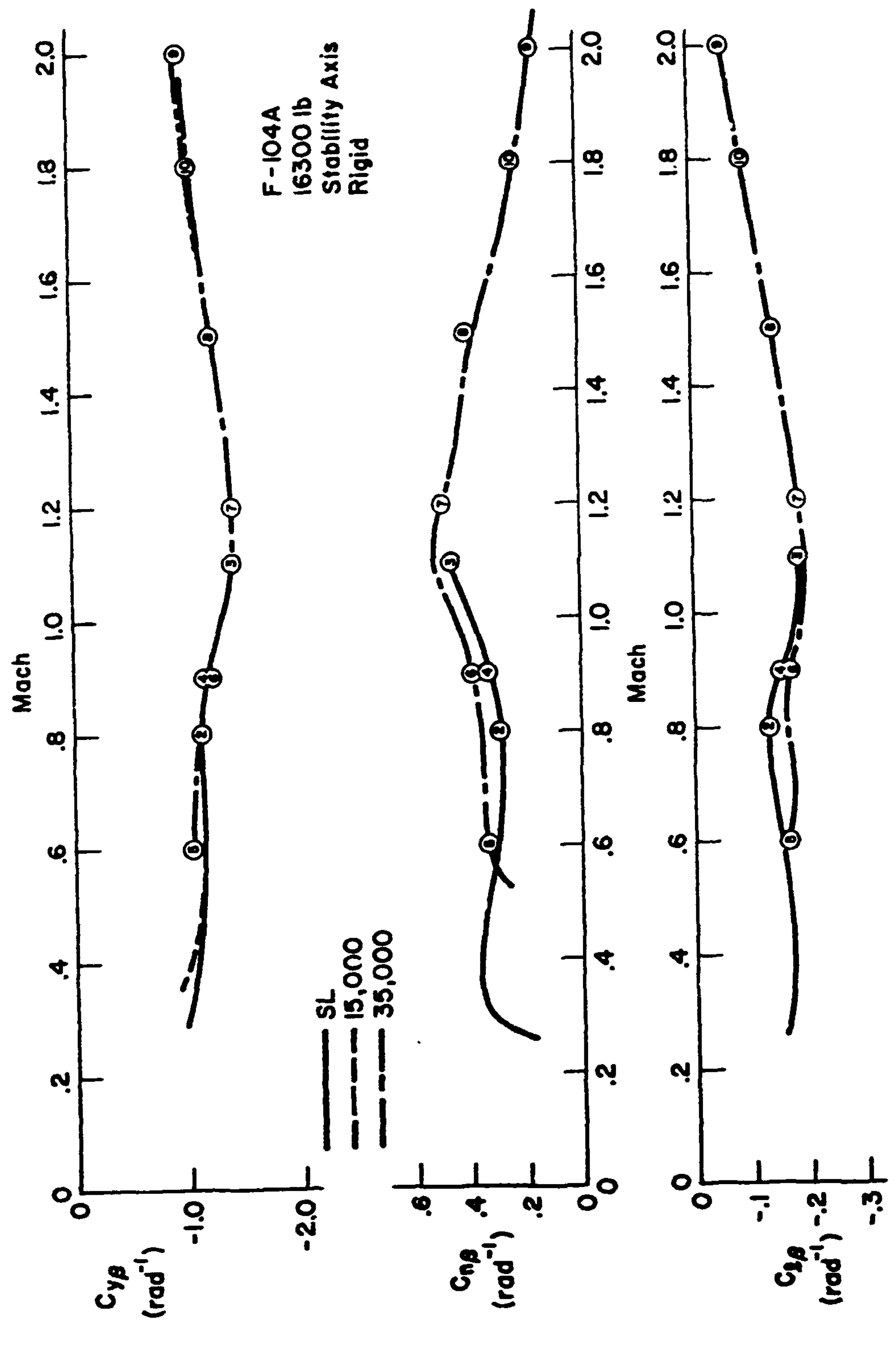

Mach
C_{m_α} (rad^{-1})
SL
15,000 ft
35,000 ft
45,000 ft
55,000 ft
F-104A
16300 lb
.070 $\bar{c}$
Rigid
Mach
$C_{m_{\dot\alpha}}$
C_{m_q}
$C_{m_{\dot\alpha}}$ C_{m_q} (rad^{-1})

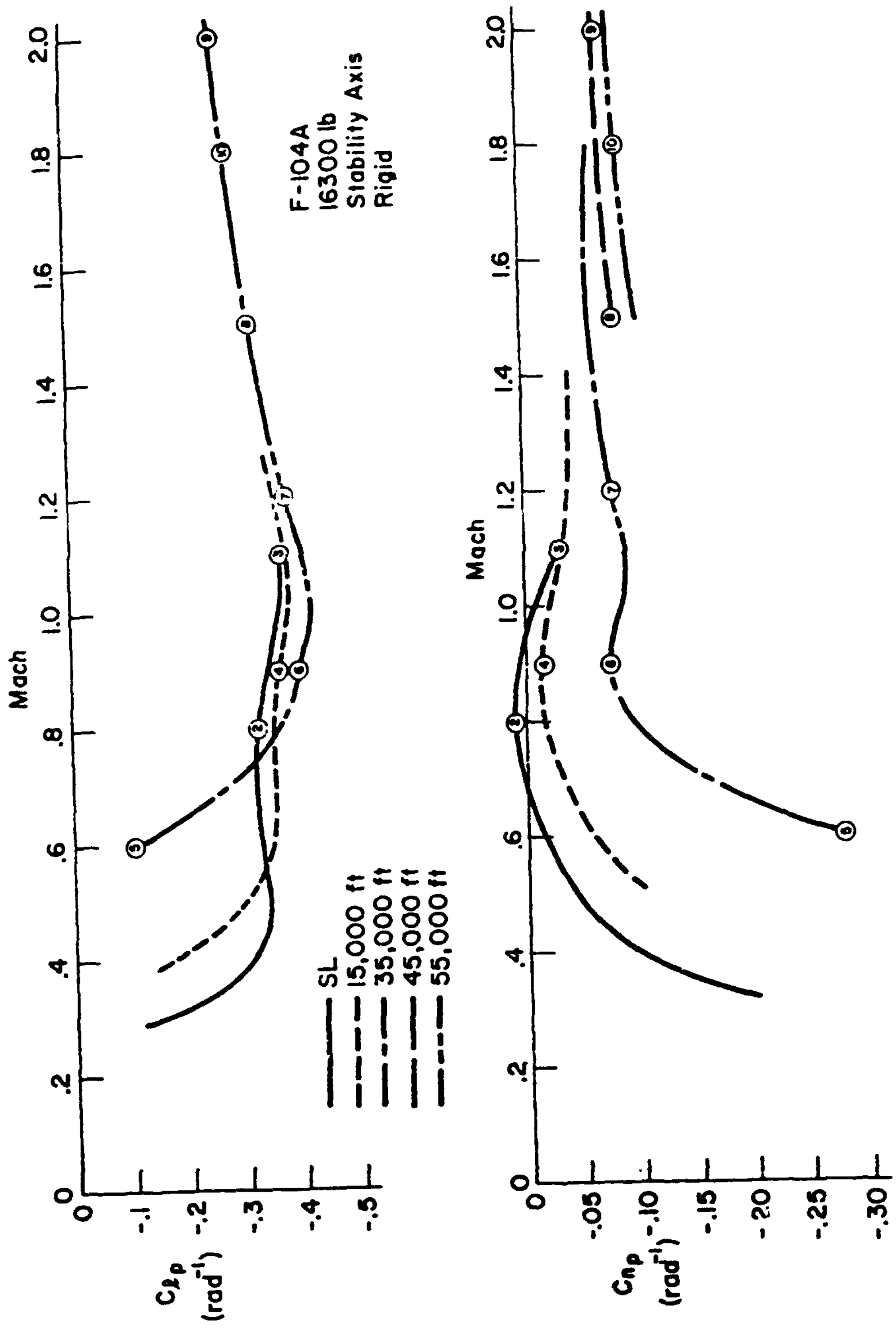


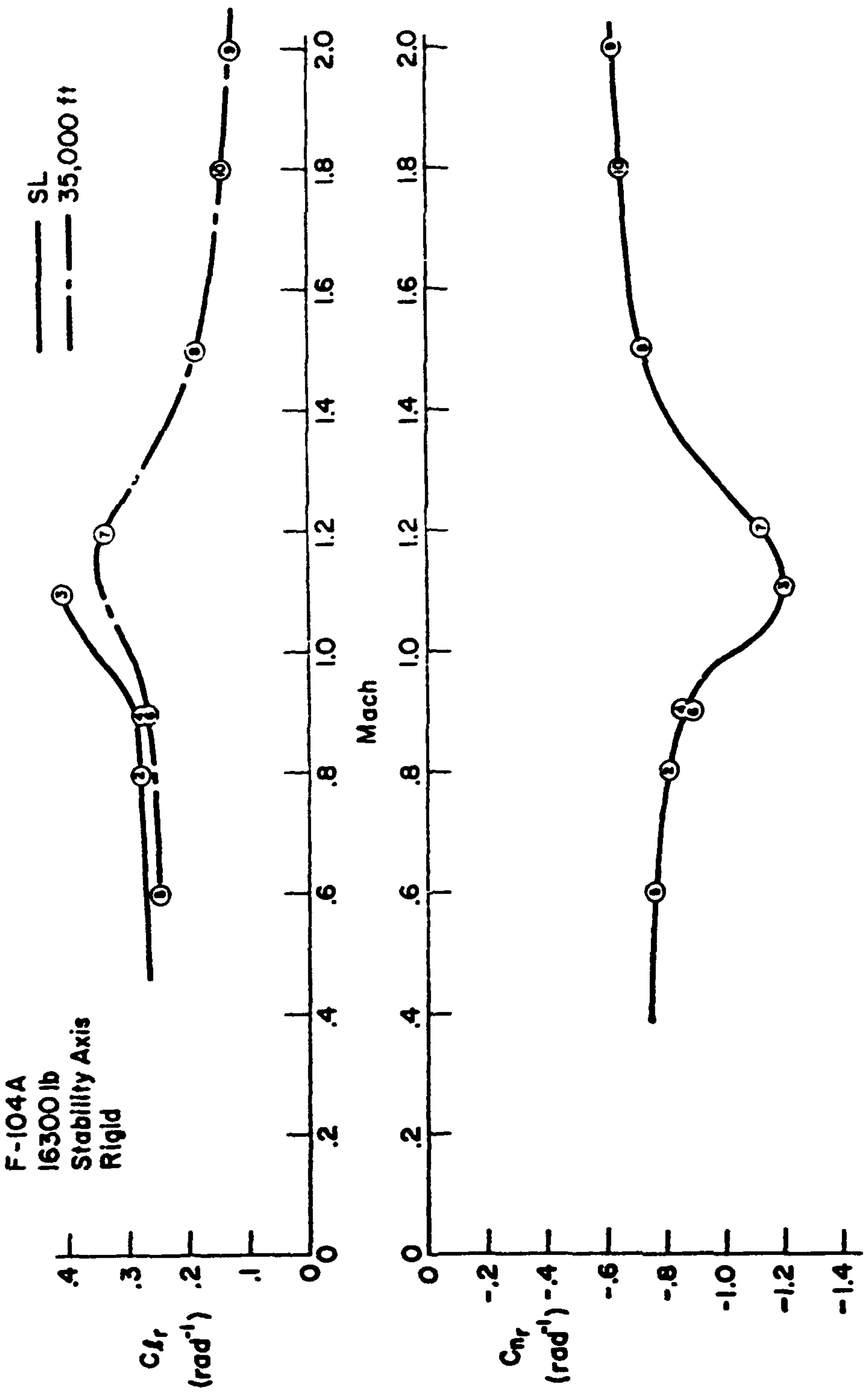
F-104A
16300 lb
Rigid
SL
15,000 ft
35,000 ft
C_{L_M}
C_{D_M}
C_{m_M}
Mach

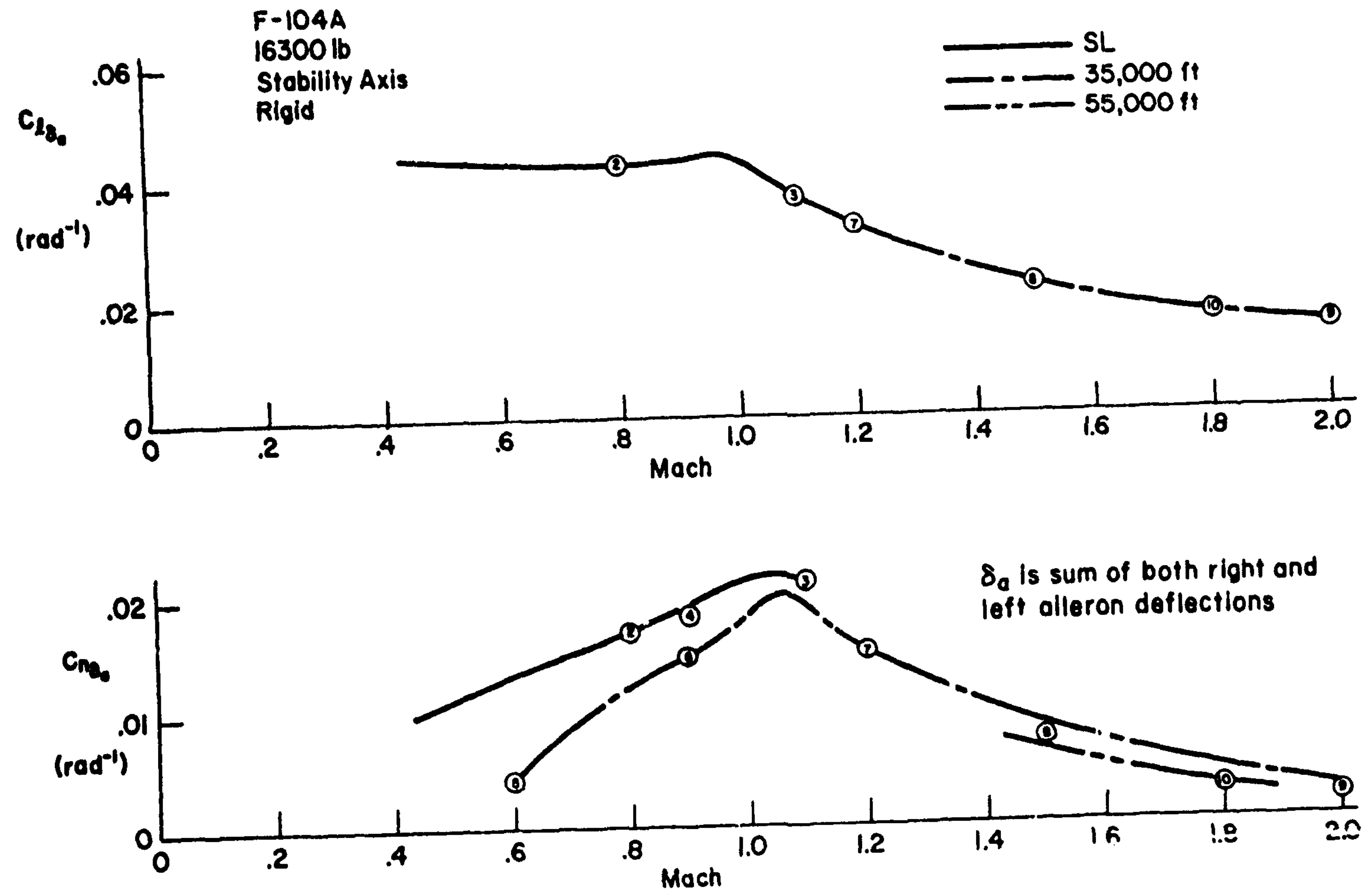


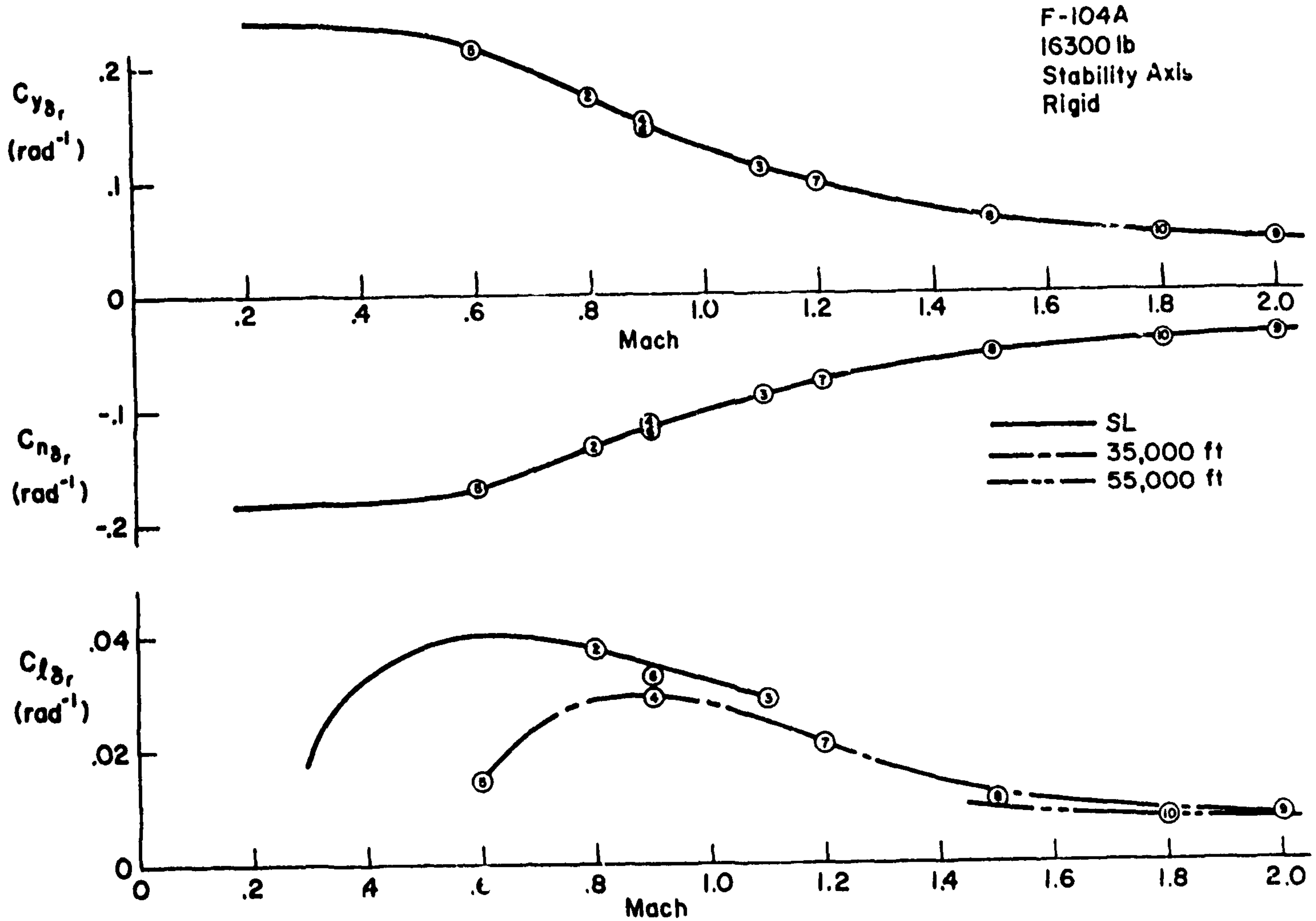
F-104A
16300 lb
Flexible
SL
35,000
55,000
$C_{L_{\delta_e}}$
(rad^{-1})
1.2
.8
.4
0
Mach
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
$C_{L_{\delta_e}}$
(rad^{-1})
-1
-2
-3


F-104A
16300 lb
Stability Axis
Rigid
SL
15,000
35,000
Mach
Cyβ (rad⁻¹)
Cnβ (rad⁻¹)
Clβ (rad⁻¹)


F-104A
16300 lb
Stability Axis
Rigid
SL
15,000 ft
35,000 ft
45,000 ft
55,000 ft
Mach
C_{l_p} (rad^{-1})
C_{n_p} (rad^{-1})


F-104A
16300 lb
Stability Axis
Rigid
SL
35,000 ft
C_{l_r} (rad^{-1})
C_{n_r} (rad^{-1})
Mach
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0
0 .1 .2 .3 .4
0 -.2 -.4 -.6 -.8 -1.0 -1.2 -1.4


F-104A
16300 lb
Stability Axis
Rigid
SL
35,000 ft
55,000 ft
$C_{l_{\delta_a}}$
(rad⁻¹)
.06
.04
.02
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Mach
δ_a is sum of both right and left aileron deflections
$C_{n_{\delta_a}}$
(rad⁻¹)
.02
.01
Mach



F-104A
16300 lb
Stability Axis
Rigid
$C_{y_{\delta_r}}$ (rad^{-1})
$C_{n_{\delta_r}}$ (rad^{-1})
$C_{l_{\delta_r}}$ (rad^{-1})
SL
35,000 ft
55,000 ft
Mach

TABLE III-2

F-104A DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMTTERS

$s = 196.1$ sq ft, $b = 21.94$ ft, $\bar{c} = 9.55$ ft

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M(-)	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
VTO(FPS)	287.	893.	1228.	952.	584.	876.	1167.	1452.	1936.	1742.
VTO(KTAS)	170.	529.	728.	564.	346.	519.	692.	860.	1147.	1032.
VTO(KCAS)	170.	529.	728.	465.	199.	311.	432.	445.	591.	433.
W(LBS)	14126.	16300.	16300.	16300.	16300.	16300.	16300.	16300.	16300.	16300.
C.G.(MGC)	.164	.0700	.0700	.0700	.0700	.0700	.0700	.0700	.0700	.0700
IX (SLUG-FT SQ)	3582.	3679.	3679.	3679.	3679.	3679.	3679.	3679.	3679.	3679.
IY (SLUG-FT SQ)	55802.	58613.	58613.	58613.	58613.	58613.	58613.	58613.	58613.	58613.
IZ (SLUG-FT SQ)	56669.	59541.	59541.	59541.	59541.	59541.	59541.	59541.	59541.	59541.
IXZ(SLUG-FT SQ)	2658.	2699.	2699.	2699.	2699.	2699.	2699.	2699.	2699.	2699.
EPSILON(DEG)	-2.86	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76
Q(PSF)	97.8	948.	1792.	677.	126.	283.	503.	489.	869.	436.
QC(PSF)	99.5	1109.	2397.	826.	138.	345.	703.	749.	1440.	706.
ALPHA(DEG)	2.30	2.00	1.00	4.80	12.4	2.50	3.00	3.80	3.00	4.80
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	19.0	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	13.1
LZP(FT)	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40
ITH(DEG)	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
XI(DEG)	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
LTH(FT)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE III-3

F-104A LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
XU *	-.0737	-.0117	-.0793	-.0167	-.00221	-.0129	-.0131	-.0125	-.0159	-.0111
ZU *	-.204	-.0332	.0270	-.0199	-.0626	-.0932	.0139	.0277	.0171	.0175
MU *	.000294	.000794	.00399	.00610	.000806	.00226	-.000998	.00124	.000457	.000708
XW	.0631	.0556	.0343	.0898	.0384	.00565	.0100	.0108	.0110	.00699
ZW	-.570	-1.65	-2.32	-1.22	-.242	-.635	-.794	-.508	-.442	-.296
MW	-.00732	-.0305	-.0816	-.0200	-.00617	-.0139	-.0283	-.0109	-.0115	-.0104
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-.000304	-.000580	-.000580	-.000478	-.000297	-.000287	-.000129	-.494E-4	-.882E-4	-.393E-4
MQ	-.317	-1.25	-1.87	-.956	-.220	-.434	-.493	-.293	-.301	-.183
XDS	1.19	8.07	7.27	17.6	8.05	4.35	7.55	7.52	7.04	7.21
ZDS	-29.7	-231.	-416.	-209.	-36.6	-99.6	-144.	-113.	-134.	-85.8
MDS	-4.79	-27.9	-63.0	-33.6	-6.03	-16.3	-23.3	-18.4	-22.2	-13.9
XDTH	.00228	.00197	.00197	.00197	.00197	.00197	.00197	.00197	.00197	.00197
ZDTH	.994E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4
MDTH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE III-4

F-104A STABILIZER TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
DENOMINATOR										
Z(DET)1	.238	.122	.767	.121	.0844	.143	(-.0299)	.716	(-.000333)	.603
W(DET)1	.152	.0504	.0523	.111	.0709	.0839	(.0389)	.00834	(.0156)	.00895
Z(DET)2	.324	.315	.263	.288	.163	.185	.125	.0810	.0967	.0643
W(DET)2	1.51	5.41	10.3	4.54	1.91	3.53	5.78	5.39	4.73	4.26
NUMERATORS										
N(U /DS)										
A(U)	1.19	8.07	7.27	17.6	8.05	4.35	7.55	7.52	7.04	7.21
1/T(U)1	43.8	147.	186.	153.	93.9	143.	189.	236.	320.	282.
Z(U)1	.740	.438	.632	.412	.690	.989	.989	.946	.797	.957
W(U)1	1.25	1.23	1.85	[illegible]65	.230	.681	.571	.359	.344	.226
N(W /DS)										
A(W)	-29.7	-231.	-416.	-209.	-36.6	-99.6	-144.	-113.	-134.	-85.8
1/T(W)1	46.6	148.	-.000664	153.	94.1	143.	-.0190	-.0174	-.0103	-.0123
1/T(W)2	(.256)	(.158)	.0791	(.178)	(.0315)	(.123)	.0300	.0266	.0245	.0204
1/T(W)3	(.150)	(.0367)	188.	(.0437)	(.0608)	(.0625)	189.	236.	320.	282.
N(THE/DS)										
A(THE)	-4.79	-37.7	-62.8	-33.5	-6.02	-16.3	-23.3	-18.4	-22.2	-13.9
1/T(THE)1	.104	.0128	.0789	.0178	.0117	.0127	.0134	.0118	.01[illegible]5	.0106
1/T(THE)2	.496	1.47	2.29	1.09	.195	.550	.620	.386	.373	.233
N(HD /DS)										
A(HD)	29.7	231.	416.	210.	37.5	99.7	144.	114.	135.	86.1
1/T(HD)1	.0504	.0106	.0784	.0132	-.0198	.00399	.0129	.0116	.0153	.0101
1/T(HD)2	-4.69	-13.8	-19.4	-12.2	-3.99	-8.48	-10.5	-9.36	-10.7	-7.96
1/T(HD)3	5.12	15.5	21.9	13.6	4.41	9.18	11.1	9.72	11.2	8.22
N(AZP/DS)										
A(AZP)	61.2	452.	720.	396.	72.3	195.	278.	220.	267.	166.
1/T(AZP)1	-.00775	-.00135	-.000458	-.00311	.00551	-.00297	-.00136	-.00135	-.000839	-.00143
1/T(AZP)2	.0575	.0120	.0789	.0162	-.0262	.00690	.0142	.0128	.0161	.0114
Z(AZP)1	.0887	.0631	.0678	.0498	.0210	.0386	.0390	.0291	.0209	.0192
W(AZP)1	3.41	10.5	15.7	9.35	3.01	6.32	7.79	6.86	7.74	5.83

TABLE III-5

F-104A THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
DENOMINATOR										
Z(DET)1	.239	.123	.767	.122	.0853	.143	(-.0299)	.716	(-.000333)	.604
W(DET)1	.152	.0504	.0523	.111	.0708	.0839	(.0389)	.00834	(.0156)	.0895
Z(DET)2	.324	.315	.263	.289	.165	.185	.125	.0810	.0968	.0643
W(DET)2	1.51	5.41	10.3	4.54	1.91	3.53	5.78	5.39	4.73	4.26
NUMERATORS										
N(U /DTH)										
A(U)	.00228	.00197	.00197	.00197	.00197	.00197	.00197	.00197	.00197	.00197
1/T(U)1	.000361	.000293	.000652	-.00128	-.00947	.119E-8	-.000218	-.000501	-.000144	-.000740
Z(U)1	.323	.316	.263	.293	.170	.187	.124	.0811	.0968	.0645
W(U)1	1.51	5.42	10.3	4.50	1.90	3.52	5.79	5.39	4.73	4.26
N(W /DTH)										
A(W)	.994E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4
1/T(W)1	.00157	.000334	.000679	-.00136	-.00993	.471E-9	-.000247	-.000501	-.000144	-.000740
Z(W)1	(-.118)	.117	.134	.0605	-.0529	-.107	(-4.67)	.0816	.101	.0645
W(W)1	(-4.09)	3.91	10.7	11.5	3.21	6.70	(5.68)	6.43	4.57	5.65
N(THE/DTH)										
A(THE)	-.242E-8	-.000E-8	-.300E-7	.380E-7	.103E-6	.355E-14	.223E-8	.222E-8	.152E-8	.313E-8
1/T(THE)1	24.0	-4.54	13.6	1.49	1.14	1.60	.538	.194	.0481	.144
1/T(THE)2	-64.1	100.	-42.5	273.	9.78	.949E+9	-1972.	330.	-55.5	218.
N(HD /DTH)										
A(HD)	-.795E-5	-.172E-4	-.517E-4	.792E-4	.000339	.146E-10	.172E-4	.448E-4	.172E-4	.792E-4
1/T(HD)1	-64.1	-10.0	-3.51	5.83	.543	.103E+8	-2.96	.151	-.0205	.119
Z(HD)1	.139	.149	.248	-.124	.135	.0769	.453	.0424	.116	.0356
W(HD)1	1.45	4.85	10.8	5.65	1.90	4.46	7.39	5.38	4.75	4.26
N(AZP/DTH)										
A(AZP)	.994E-4	.863E-4	.866E-4	.854E-4	.842E-4	.861E-4	.861E-4	.861E-4	.861E-4	.860E-4
1/T(AZP)1	-.00451	-.00126	-.000458	-.00284	-.0122	-.00161	- 45	-.00150	-.000767	-.00157
1/T(AZP)2	-4.79	-1.63	-2.25	-5.05	-1.96	-3.65	.982	-.0763	.00466	-.107
Z(AZP)1	.194	.265	.255	.328	.168	.195	.0805	.0869	.0947	.0738
W(AZP)1	1.50	5.38	10.4	5.83	1.99	3.87	5.71	5.40	4.72	4.27

TABLE III-6

F-104A STICK FORCE TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.700	.900	1.20	1.50	2.00	1.80
DENOMINATOR										
Z(DET)1	.249	.151	.990	[illegible]7	.0717	.134	(-.0266)	.776	(-.000450)	.644
W(DET)1	.142	.0387	.0401	.0451	.0683	.0749	(.0363)	.00765	(.0157)	.00832
Z(DET)2	.303	.239	.199	.218	.156	.164	.113	.0754	.0830	.0602
W(DET)2	1.59	6.31	11.3	5.35	1.95	3.76	5.91	5.45	5.02	4.33
NUMERATORS										
N(U /FST)										
A(U)	-.00565	-.0265	-.0213	-.0591	-.0317	-.0161	-.0268	-.0275	-.0252	-.0270
1/T(U)1	43.8	147.	186.	153.	93.9	143.	189.	236.	320.	282.
Z(U)1	.740	.438	.632	.412	.690	.989	.959	.946	.797	.957
W(U)1	1.25	1.23	1.85	.665	.230	.681	.571	.359	.344	.226
N(W /FST)										
A(W)	.141	.760	1.22	.704	.144	.369	.512	.414	.480	.322
1/T(W)1	46.6	148.	-.000664	153.	94.1	143.	-.0190	.0174	-.0103	-.0123
1/T(W)2	(.256)	(.158)	.0791	(.178)	(.0315)	(.123)	.0300	.0266	.0245	.0204
1/T(W)3	(.150)	(.0367)	188.	(.0437)	(.0608)	(.0625)	189.	236.	320.	282.
N(THE/FST)										
A(THE)	.0227	.124	.184	.113	.0237	.0602	.0829	.0674	.0794	.0523
1/T(THE)1	.104	.0128	.0789	.0178	.0117	.0127	.0134	.0118	.0155	.0106
1/T(THE)2	.496	1.47	2.29	1.09	.195	.550	.620	.386	.373	.231
N(HD /FST)										
A(HD)	-.141	-.761	-1.22	-.707	-.148	-.369	-.513	-.415	-.481	-.323
1/T(HD)1	.0504	.0106	.0784	.0132	-.0198	.00399	.0129	.0116	.0153	.0101
1/T(HD)2	-4.69	-13.8	-19.4	-12.2	-3.99	-8.48	-10.5	-9.36	-10.7	-7.96
1/T(HD)3	5.12	15.5	21.9	13.6	4.41	9.18	11.1	9.72	11.2	8.22
N(AZP/FST)										
A(AZP)	-.290	-1.49	-2.11	-1.34	-.285	-.720	-.988	-.805	-.956	-.625
1/T(AZP)1	-.00775	-.00135	-.000458	-.00311	.00551	-.00297	-.00136	-.00135	-.000839	-.00143
1/T(AZP)2	.0575	.0120	.0789	.0162	-.0262	.00690	.0142	.0128	.0161	.0114
Z(AZP)1	.0887	.0621	.0678	.0498	.0210	.0386	.0390	.0291	.0209	.0192
W(AZP)1	3.41	10.5	15.7	9.35	3.01	6.37	7.79	6.86	7.74	5.83

TABLE III-7

F-104A THRUST TRANSFER FUNCTION FACTORS

SAL Off — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	4[illegible] K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
DENOMINATOR										
Z(DET)1	.249	.151	.990	.127	.0725	.134	(-.0266)	.777	(-.000450)	.644
W(DET)1	.142	.0387	.0401	.0851	.0683	.0749	(.0363)	.00765	(.0157)	.00832
Z(DET)2	.303	.239	.199	.218	.158	.164	.113	.0755	.0836	.0602
W(DET)2	1.59	6.31	11.3	5.35	1.95	3.76	5.91	5.45	5.02	4.33
NUMERATORS										
N(U /DTH)										
A(U)	.00228	.00197	.00197	.00197	.00197	.00197	.00197	.00197	.00197	.00197
1/T(U)1	-.000293	-.000339	.000203	-.00193	-.00967	-.000328	-.000443	-.000624	-.000308	-.000831
Z(U)1	.302	.238	.198	.216	.158	.164	.111	.0730	.0804	.056
W(U)1	1.59	6.31	11.3	5.33	1.94	3.76	5.02	5.45	5.02	4.33
N(W /DTH)										
A(W)	.000101	.926E-4	.966E-4	.921E-4	.873E-4	.893E-4	.905E-4	.896E-4	.902E-4	.889E-4
1/T(W)1	-.00555	.00585	.000650	-.00115	-.00935	.000740	.519E-4	-.000608	-.000310	-.000809
Z(W)1	(.605)	(.244)	(4.20)	.566	.164	.336	(-1.53)	.814	(1.60)	.846
W(W)1	(-4.19)	(10.5)	(17.8)	5.43	2.78	5.18	(11.6)	6.32	(13.8)	5.57
N(THE/DTH)										
A(THE)	.221E-6	.105E-5	.156E-5	.593E-6	.301E-6	.515E-6	.711E-6	.578E-6	.681E-6	.450E-6
1/T(THE)1	(-.531)	(-.429)	(.0874)	2.83	(.669)	(.565)	.532	.142	-.0204	.128
1/T(THE)2	(4.03)	(1.86)	(2.82)	4.53	(1.92)	(3.08)	-5.44	1.46	.256	1.56
N(HD /DTH)										
A(HD)	-.934E-5	-.237E-4	-.622E-4	.732E-4	.000338	-.316E-5	.128E-4	.412E-4	.131E-4	.765E-4
1/T(HD)1	-55.4	-11.4	-4.52	3.78	.495	-79.8	-1.87	.106	-.00763	.0940
Z(HD)1	.159	.680	.363	.0712	.142	.215	.315	.0372	.0709	.0331
W(HD)1	1.41	3.48	7.37	6.62	1.95	4.12	10.0	6.33	8.41	4.67
N(AZP/DTH)										
A(AZP)	.965E-4	.735E-4	.684E-4	.741E-4	.919E-4	.799E-4	.776E-4	.792E-4	.779E-4	.807E-4
1/T(AZP)1	-.00451	-.00126	-.000458	-.00284	-.0122	-.00161	-.00146	-.00150	-.000767	-.00157
1/T(AZP)2	-4.79	-1.63	-2.24	-4.95	-1.95	-3.64	.482	-.0763	.00466	-.107
Z(AZP)1	.193	.261	.251	.325	.168	.194	.0775	.0870	.0943	.0741
W(AZP)1	1.49	5.23	9.98	5.72	1.98	3.83	5.61	5.32	4.64	4.23

TABLE III-8

F-104A LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.600	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
STICK FIXED										
D(G)/D(U) (DEG/KT)	-.192	-.0319	-.236	-.0357	.0594	-.0120	-.0388	-.0348	-.0440	-.0305
N/A (G/RAD)	4.64	40.3	86.3	32.0	3.62	14.9	22.4	17.4	22.3	12.5
DE/G (DEG/G)	5.83	1.09	1.10	1.07	9.36	2.92	3.66	5.17	2.57	5.92
CAP (RAD/SEC/SEC/G)	.487	.719	1.21	.623	.983	.829	1.49	1.66	.995	1.44
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	--	(23.2)	--	(2080.)	--
T/C(1/10)	.933	.907	.744	.823	.455	.515	.343	.222	.266	.176
STICK FREE										
FST/KT (LB/KT)	-.223	-.0171	-.0254	-.0875	-.189	-.126	.0345	-.00351	.000317	-.00563
FST/G (LB/G)	23.9	7.84	7.90	7.74	43.1	15.7	18.8	25.3	14.2	28.5

TABLE III-9

F-104A LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.860	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
YV	-.178	-.452	-.791	-.328	-.0868	-.149	-.234	-.160	-.170	-.102
YB	-51.1	-404.	-971.	-312.	-50.7	-130.	-273.	-233.	-330.	-177.
LB'	-20.9	-146.	-363.	-134.	-32.3	-58.1	-115.	-87.8	-64.3	-52.2
NB'	2.68	13.6	42.7	9.91	1.06	4.98	11.9	9.79	6.92	4.62
LP'	-1.38	-4.64	-7.12	-3.63	-.374	-1.77	-2.27	-1.46	-1.59	-.962
NP'	-.0993	-.188	-.341	-.150	-.0406	-.0943	-.117	-.0804	-.0901	-.0544
LR'	1.16	3.67	7.17	2.66	1.02	1.08	1.88	.822	.689	.469
NR'	-.157	-.498	-1.06	-.350	-.0809	-.169	-.292	-.152	-.188	-.106
Y*CA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
L'CA	4.76	49.6	81.5	34.7	6.35	14.8	19.4	12.9	15.8	8.38
N'CA	.266	3.51	6.50	2.64	.407	1.01	1.49	.902	.890	.517
Y*DR	.0317	.0719	.0621	.0413	.0179	.0188	.0159	.00847	.00782	.00485
L'DR	5.35	41.5	57.6	27.6	6.66	11.2	13.1	7.17	8.68	5.04
N'DR	-.923	-7.07	-8.72	-4.49	-1.18	-1.91	-2.09	-1.52	-1.78	-1.01

TABLE III-10

F-104A AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
DENOMINATOR										
1/T(DET)1	-.000594	.00711	.00404	.00849	.0172	.00849	.00570	.00368	.00588	.00602
1/T(DET)2	1.84	4.82	7.86	3.08	.446	2.04	2.41	1.50	1.72	.941
Z(DET)1	-.0345	.0849	.0732	.136	.0138	.00590	.0453	.0339	.0331	.0373
W(DET)1	2.10	4.51	7.53	4.50	2.84	2.85	4.29	3.97	3.25	3.00
NUMERATORS										
N(B /DA)										
A(B)	-.0749	-1.78	-5.08	.275	.966	-.369	-.468	-.0432	-.0631	.187
1/T(B)1	.170	-.308	-.229	-.447	.0864	.317	-.596	.295	.127	.111
1/T(B)2	-9.28	2.48	3.00	-5.36	.586	-1.13	.843	-4.74	-7.43	1.01
N(P /DA)										
A(P)	4.76	46.6	81.5	34.7	6.35	14.8	19.4	12.9	15.8	8.38
1/T(P)1	-.00446	-.00124	-.000450	-.00282	-.0121	-.00160	-.00144	-.00147	-.000868	-.00155
Z(P)1	.103	.123	.142	.0983	.0699	.0656	.0737	.0466	.0612	.0426
W(P)1	1.97	4.93	8.54	4.49	1.76	3.00	4.55	3.99	3.25	2.80
N(R /DA)										
A(R)	.266	3.51	6.50	2.64	.407	1.01	1.49	.902	.890	.517
1/T(R)1	1.48	1.08	1.61	.405	.249	.804	.528	.334	.316	.220
Z(R)1	-.372	.202	.265	.169	-.0646	-.0533	.0591	.0170	-.0252	-.00604
W(R)1	2.28	3.35	3.83	4.69	3.25	2.44	3.75	3.89	3.14	3.27
N(PHI/DA)										
A(PHI)	4.77	45.7	81.7	34.9	6.44	14.8	19.5	13.0	15.8	8.43
Z(PHI)1	.101	.123	.142	.0987	.0639	.0655	.0737	.0464	.0610	.0423
W(PHI)1	1.97	4.92	8.53	4.49	1.78	3.00	4.55	3.99	3.25	2.80
N(AYP/DA)										
A(AYP)	16.5	183.	313.	131.	22.6	53.8	73.6	47.3	53.9	29.5
1/T(AYP)1	-.278	-.176	-.169	-.154	.111	-.146	-.144	-.114	.116	.0988
1/T(AYP)2	.343	.721	.961	.505	-.290	.250	.301	.164	-.289	-.167
Z(AYP)1	.0370	.112	.128	.104	.0760	.0574	.0695	.0444	.0758	.0520
W(AYP)1	1.96	4.87	8.16	4.49	1.85	2.96	4.48	3.98	3.29	2.76

TABLE III-11

F-104A RUDDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
DENOMINATOR										
1/T(DET)1	.00594	.00711	.00404	.00849	.0172	.00949	.00570	.00368	.00588	.00602
1/T(DET)2	.86	4.82	7.86	3.08	.446	2.04	2.41	1.50	1.72	.941
Z(DET)1	-.0345	.0849	.0732	.136	.0138	.00590	.0453	.0339	.0331	.0373
W(DET)1	2.10	4.51	7.53	4.50	2.84	2.85	4.29	3.97	3.25	3.00
NUMERATORS										
N(B /DR)										
A(B)	.0317	.0719	.0621	.0413	.0179	.0188	.0159	.00847	.00782	.00485
1/T(B)1	-.0139	-.00574	-.00100	-.00640	-.0439	-.00267	-.00171	-.00256	.000969	-.000579
1/T(B)2	2.16	4.94	8.64	3.11	.391	2.02	2.40	1.48	1.69	.938
1/T(B)3	35.3	119.	156.	165.	144.	128.	175.	235.	285.	294.
N(P /DR)										
A(P)	5.35	41.5	57.6	27.6	6.66	11.2	13.1	7.17	8.68	5.04
1/T(P)1	-.00447	-.00129	-.000454	-.00283	-.0121	-.00160	-.00144	-.00147	-.000872	-.00155
1/T(P)2	-.960	-3.32	-3.33	-3.42	2.09	-2.19	-2.49	-2.95	-2.42	-2.37
1/T(P)3	.976	3.40	3.70	3.47	-2.18	2.23	2.58	2.98	2.58	2.44
N(R /DR)										
A(R)	-.923	-7.07	-8.72	-4.49	-1.18	-1.91	-2.09	-1.52	-1.78	-1.01
1/T(R)1	2.01	5.41	9.26	.498	.254	1.95	2.27	.397	.477	.236
Z(R)1	.0299	.493	.627	.966	.0889	.320	.635	.508	.820	.358
W(R)1	.548	.662	.478	2.22	2.36	.736	.699	1.52	1.03	1.51
N(PHI/DR)										
A(PHI)	5.32	41.2	57.4	27.2	6.40	11.2	13.0	7.07	8.58	4.95
1/T(PHI)1	.972	-3.36	-3.35	3.47	2.16	-2.21	-2.52	-2.99	-2.45	-2.42
1/T(PHI)2	-.974	3.39	3.69	-3.49	-2.30	2.23	2.58	3.00	2.58	2.46
N(AYP/DR)										
A(AYP)	4.40	35.8	56.7	24.3	5.13	8.79	12.2	2.04	3.83	2.30
1/T(AYP)1	-.0277	-.0129	-.00460	-.0144	-.0582	-.0100	-.00748	-.00671	-.000431	-.00323
1/T(AYP)2	-6.66	-16.6	-22.9	2.25	.209	1.46	2.00	.897	1.40	.622
1/T(AYP)3	(.611)	(.787)	(.612)	4.85	5.75	3.03	3.74	8.86	8.88	8.20
1/T(AYP)4	(1.43)	(4.07)	(6.05)	-16.5	-8.08	-10.3	-11.4	-25.9	-20.6	-19.0

TABLE III-12

F-104A LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

A/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
DR PERIOD (SEC)	3.00	1.40	.836	1.41	2.22	2.21	1.47	1.59	1.93	2.10
1/C(1/2)	--	.773	.665	1.24	.125	.0535	.411	.308	.300	.338
SPIRAL (2) (SEC)	1167.	--	--	--	--	--	--	--	--	--
P(1)	2.47	13.2	15.0	11.1	2.60	8.04	8.72	8.51	9.14	7.28
P(2)	1.66	11.2	11.7	10.8	1.37	7.12	8.42	8.48	8.79	7.10
P(3)	2.86	12.8	14.5	11.0	4.89	8.44	9.31	8.61	9.06	7.66
P(2)/P(1)	.671	.847	.783	.973	.525	.885	.966	.997	.963	.975
P(OSC)/P(AV)	.232	.0751	.114	.0111	.466	.0732	.0340	.00440	.0170	.0256
W(PHI)/W(D)	.940	1.09	1.13	.999	.629	1.05	1.06	1.01	1.00	.934
DEL-B-MAX	.170	.0908	.0873	.0302	.261	.0954	.0456	.0129	.0383	.0427
PHI TO BETA, PHASE	-318.	44.3	44.9	390.	-353.	33.6	26.4	18.2	-336.	14.8
PHI TO BETA	3.94	5.31	4.92	5.59	3.98	6.12	5.64	5.28	5.54	5.56
PHI TO VE	.787	.341	.230	.424	.701	.719	.497	.472	.371	.526

F-104A DATA SOURCES

Stability and Control and Handling Qualities, F-104A, Lockheed Rept. No. LR 10794, 12 Dec. 1955

Andrews, William H., and Herman A. Rediess, Flight-Determined Stability and Control Derivatives of a Supersonic Airplane with a Low Aspect-Ratio Unswept Wing and a Tee-Tail, NASA Memo 2-2-59H, Apr. 1959

Performance, F-104D, Lockheed Rept. No. LR-12873, 1 May 1958

Flight Manual, F-104A and F-104B USAF Series Aircraft, T. O. 1F-104A-1, 15 Dec. 1961

Technical Manual, Flight Controls, USAF Series F-104A and F-104C Aircraft, T. O. 1F-104A-2-8, 15 Mar. 1960

SECTION IV

F-4C

F-4C BACKGROUND

The F-4C is an Air Force tactical fighter whose primary mission is all-weather air-to-air missile combat. Lateral control is achieved by ailerons in combination with spoilers on a swept wing. A swept stabilator provides longitudinal stability and control. Directional stability and control is accomplished through a conventional fin-rudder combination. Landing speed is reduced by full span leading edge flaps and inboard plain trailing edge flaps in conjunction with blowing-type boundary layer control (BLC). Boundary layer control is automatically induced when full flap deflection occurs.

Features distinguishing the USAF F-4C from its Navy counterpart, the F-4B, are:

- Lack of drooped ailerons with flaps down resulting in higher landing speeds.
- Dual flight controls resulting in slightly increased control system inertia.
- Wing bumps to house larger main gear wheels resulting in a slight drag increase.

Data included here was obtained primarily from MAC Report No. 9842. Special emphasis is placed on the longitudinal control system because of its relative complexity when compared to other aircraft. Figure IV-4 has been added to help illustrate this system. Also, care has been taken to retain some of the control system nomenclaure used by the manufacturer, e.g., q_B and P_{BP} (see Fig. IV-5).

The Stability Augmentation block diagrams are shown in Fig. IV-7. The roll SAS described is not included in lateral directional SAS on transfer functions since it is faded out with the lateral control stick out of neutral position.

F-4C

NOMINAL CONFIGURATION

4 AIM-7 missiles

60% internal fuel

W = 38924 lb

c.g. at 0.289 $\bar{c}$, W.L. 27.65

$\left.\begin{array}{l} I_x = 25001 \text{ slug-ft}^2 \\ I_y = 122186 \text{ slug-ft}^2 \\ I_z = 139759 \text{ slug-ft}^2 \\ I_{xz} = 2177 \text{ slug-ft}^2 \end{array}\right\}$ body axis

POWER APPROACH CONFIGURATION

2 AIM-7 missiles aft

20% internal fuel

Full flaps, BLC

Gear down

19 units angle of attack

W = 33196 lb

c.g. at 0.291 $\bar{c}$, W.L. 25.2

$\left.\begin{array}{l} I_x = 23668 \text{ slug-ft}^2 \\ I_y = 117500 \text{ slug-ft}^2 \\ I_z = 133723 \text{ slug-ft}^2 \\ I_{xz} = 15\text{[illegible]} \text{ slug-ft}^2 \end{array}\right\}$ body axis

FLIGHT ENVELOPE

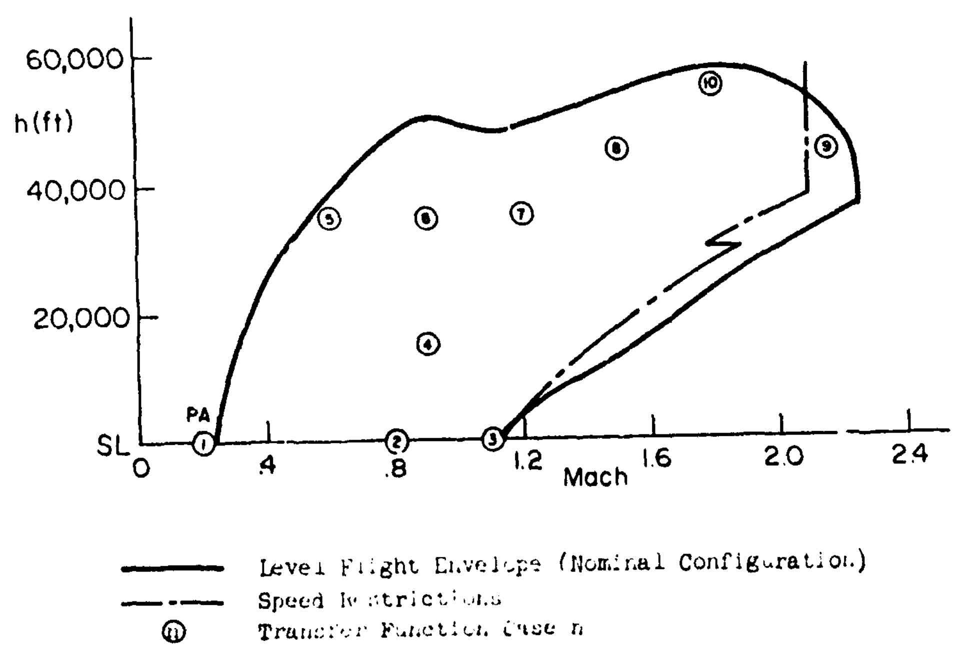


Figure IV-1. Flight Conditions

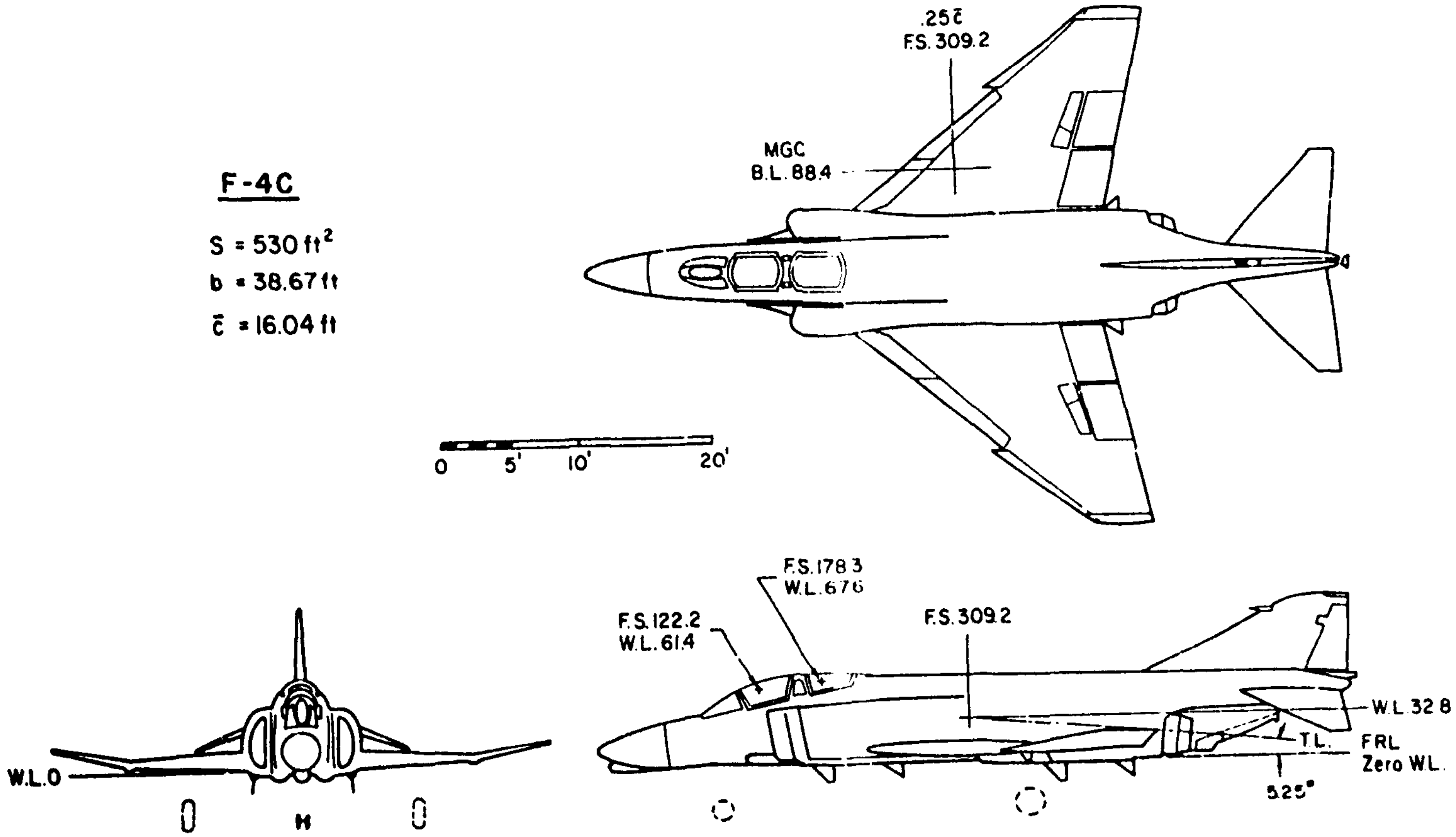
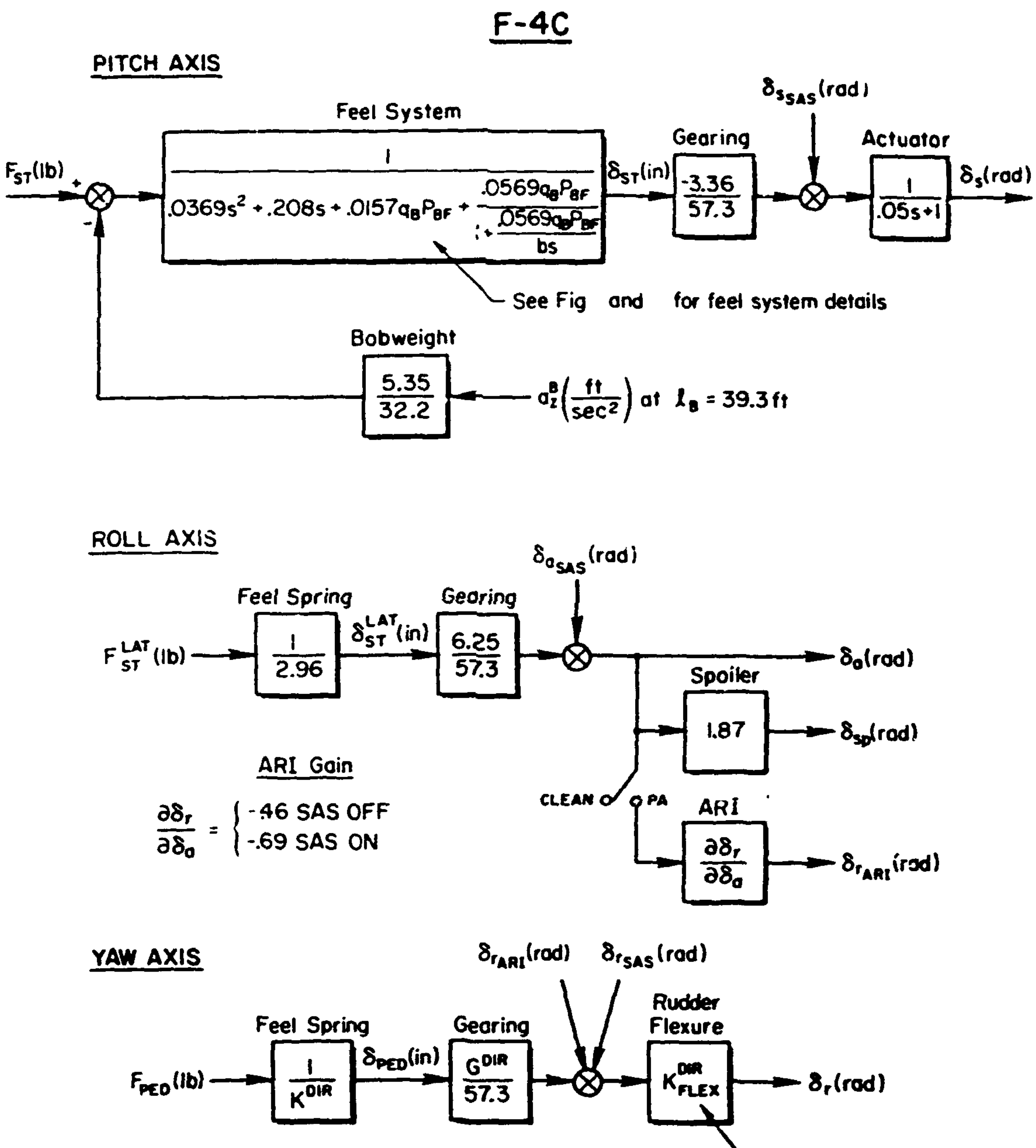
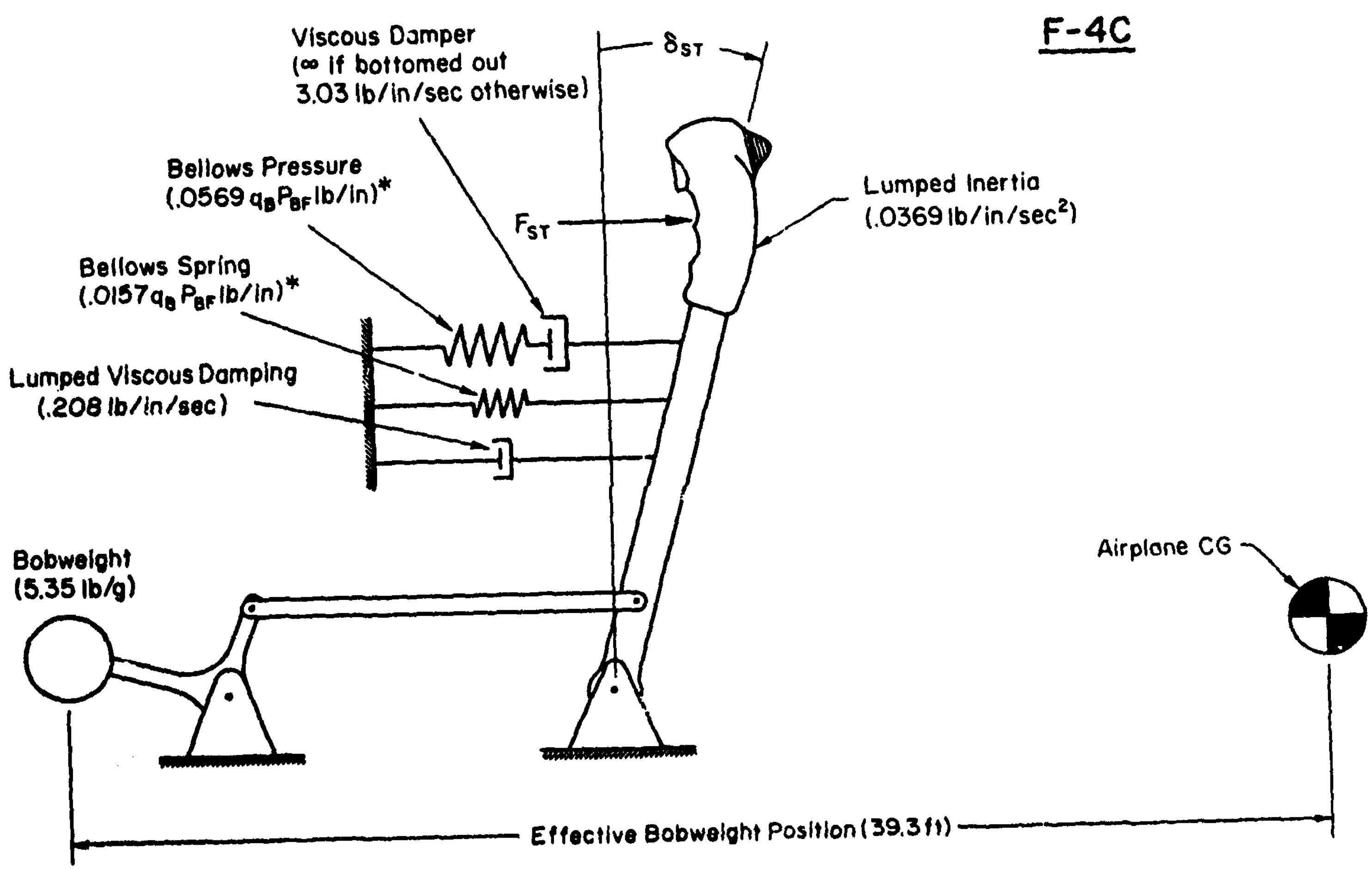


Figure IV-2. F-4C General Arrangement



	K^{DIR}	G^{DIR}
V < 235 KIAS	36.6 lb/in	-11.5 deg/in
V > 220 KIAS	8.5 lb/in	-6.5 deg/in

Figure IV-3. F-4C Control System



* The product $q_B P_{BF}$ is determined by the mach, q, and δ_s combination at a particular flight condition. See Fig. IV-5 for nominal configuration values

Figure IV-4. F-4C Feel System Schematic

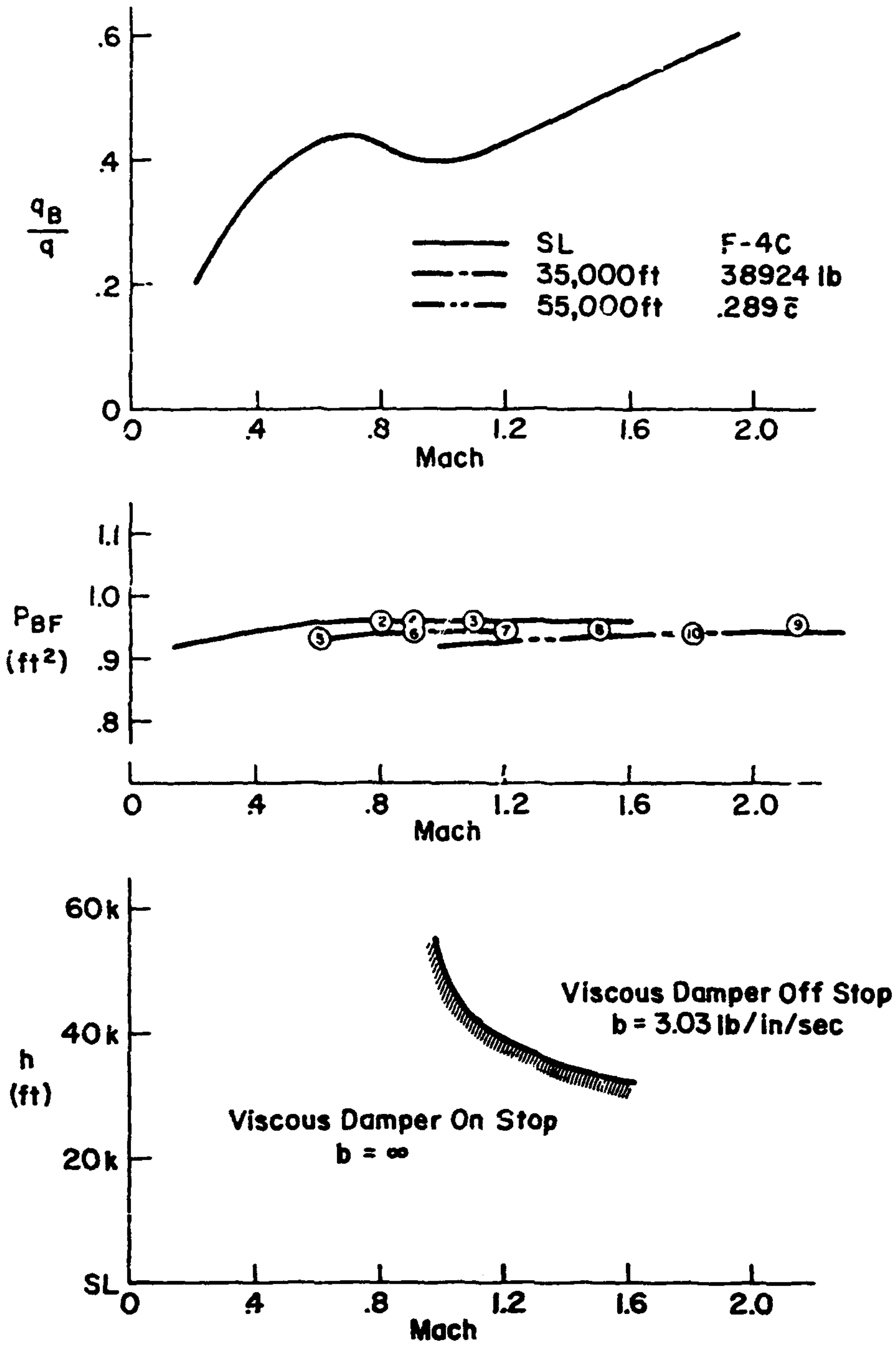


Figure IV-5. F-4C Feel System Parameters

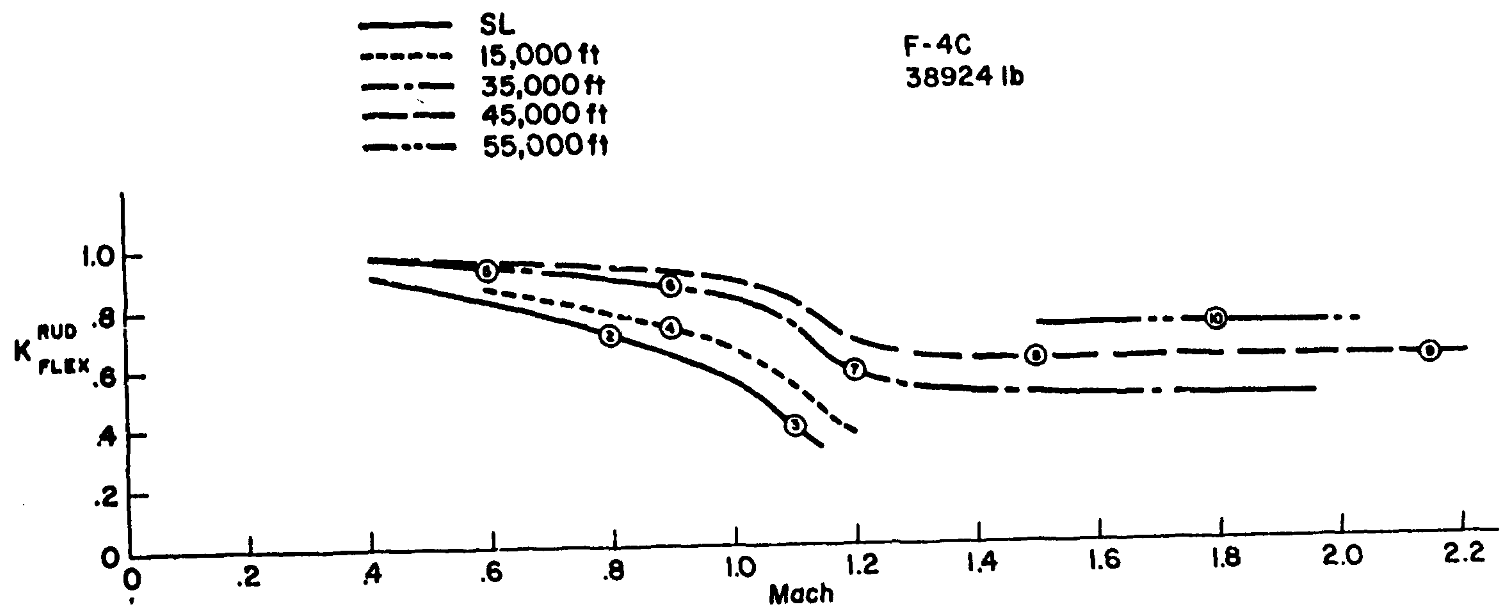


Figure IV-6. F-4C Rudder Flexure Coefficient

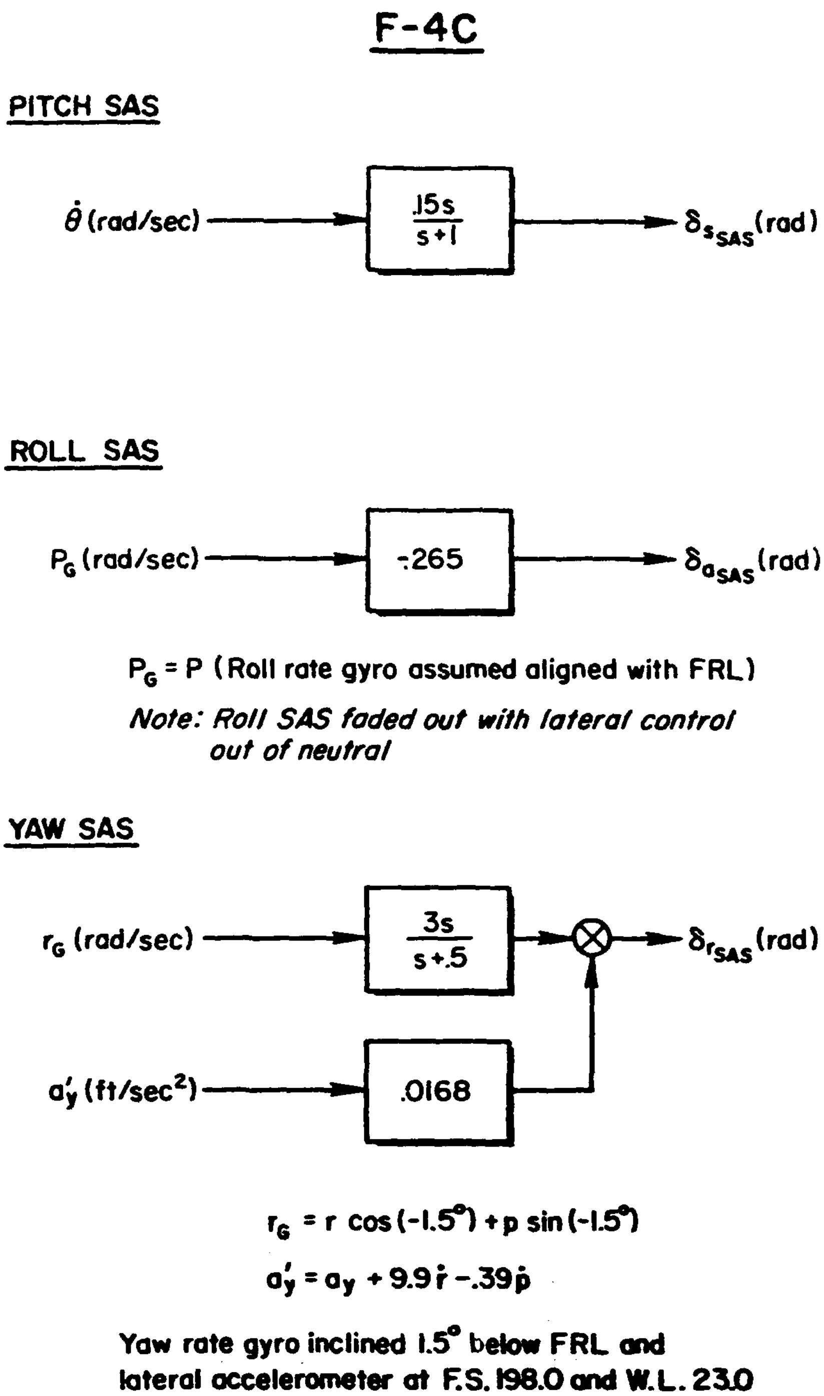


Figure IV-7. F-4C Stability Augmentation

TABLE IV-1

F-4C

Power Approach Non-Dimensional Stability Derivatives

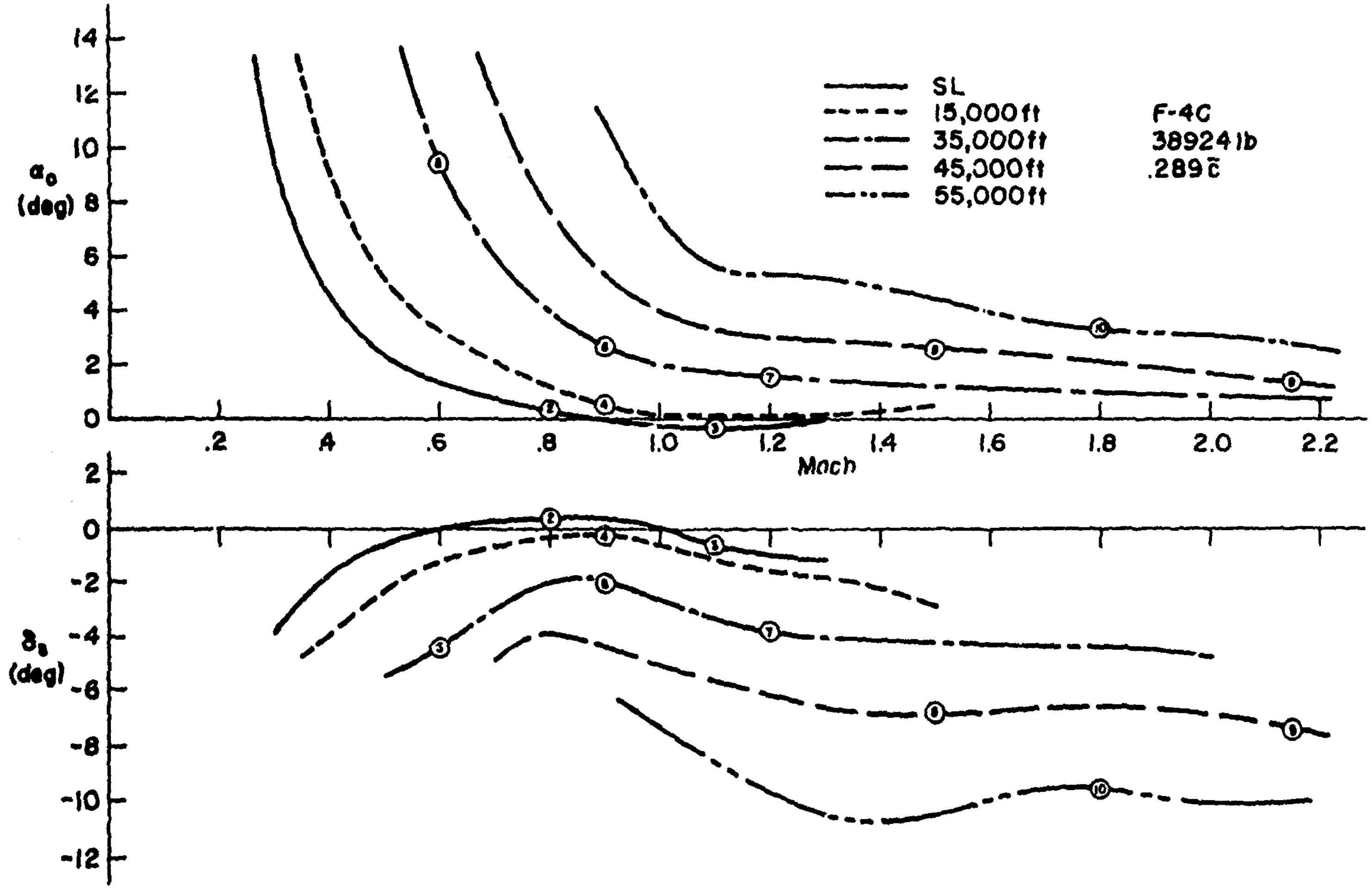
h = sea level

V_{T_o} = 230 ft/sec = 136 kt

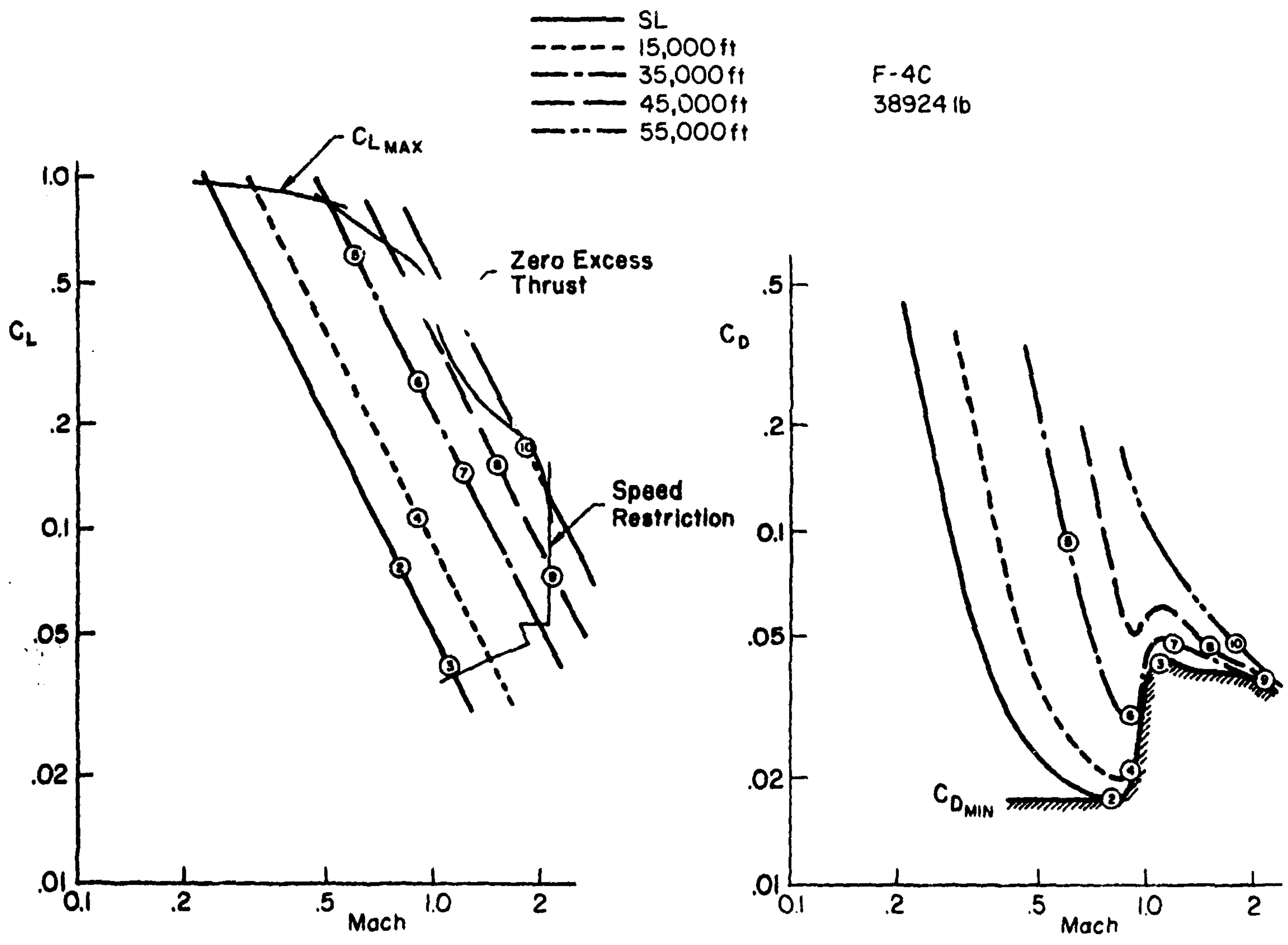
α_o = 11.7°

δ_s = −9.1°

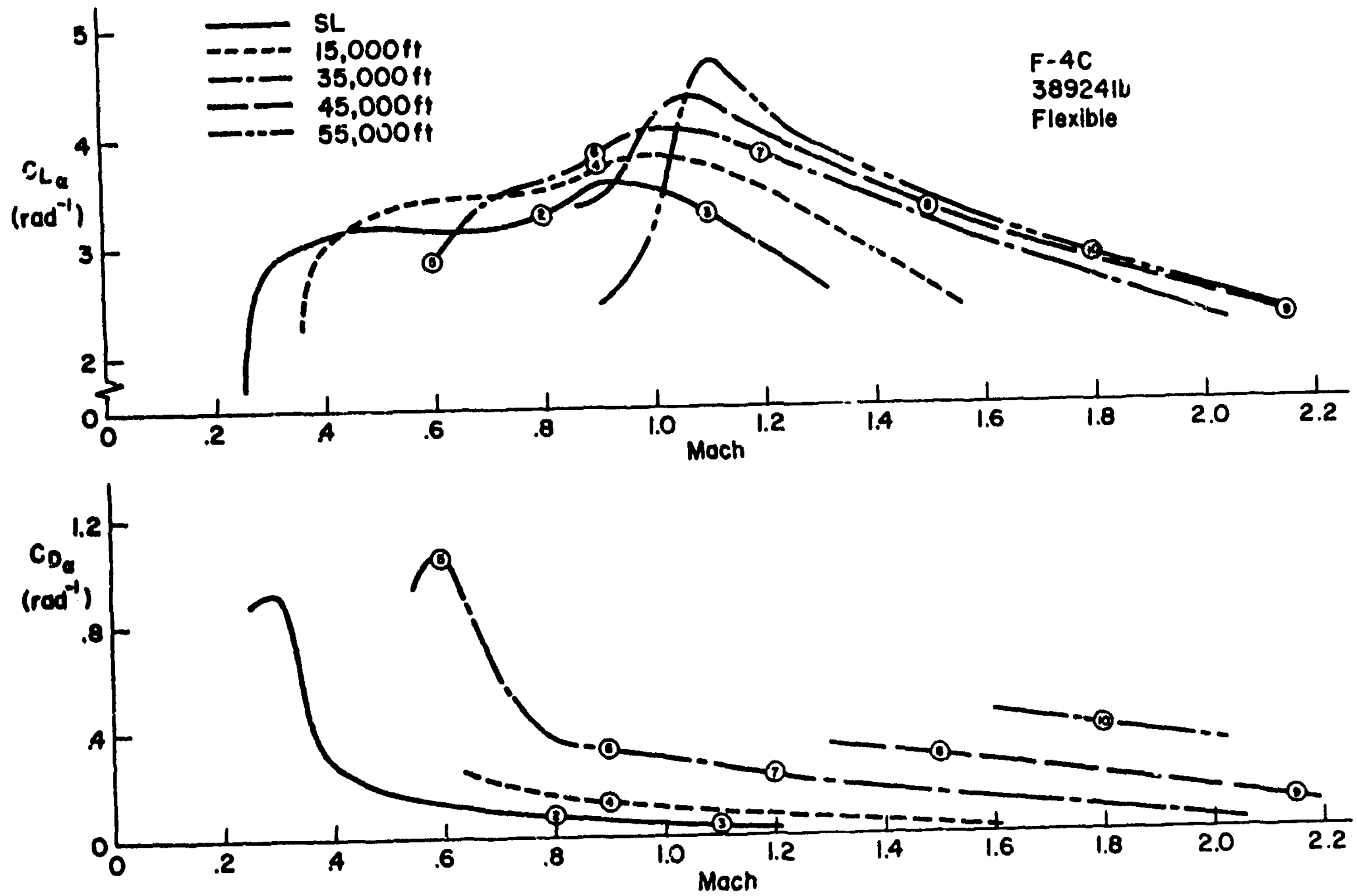
Longitudinal		Lateral-Directional (Stability Axis)	
C_L	= .915	C_{y_β}	= −.655/rad
C_D	= .242	C_{n_β}	= .199/rad
C_{L_α}	= 2.8/rad	C_{ℓ_β}	= −.156/rad
C_{D_α}	= .555/rad	C_{ℓ_p}	= −.272/rad
C_{m_α}	= −.098/rad	C_{n_p}	= −.013/rad
$C_{m_{\dot\alpha}}$	= −.95/rad	C_{ℓ_r}	= .205/rad
C_{m_q}	= −2.0/rad	C_{n_r}	= −.320/rad
$C_{L_{\delta_s}}$	= .24/rad	$C_{y_{\delta_a}}$	= −.0355/rad (Spoiler Effects Included)
$C_{m_{\delta_s}}$	= −.322/rad	$C_{n_{\delta_a}}$	= −.0041/rad (Spoiler Effects Included)
$C_{D_{\delta_s}}$	= −.14/rad	$C_{\ell_{\delta_a}}$	= .057/rad (Spoiler Effects Included)
		$C_{y_{\delta_r}}$	= .124/rad
		$C_{n_{\delta_r}}$	= −.072/rad
		$C_{\ell_{\delta_r}}$	= −.0009/rad

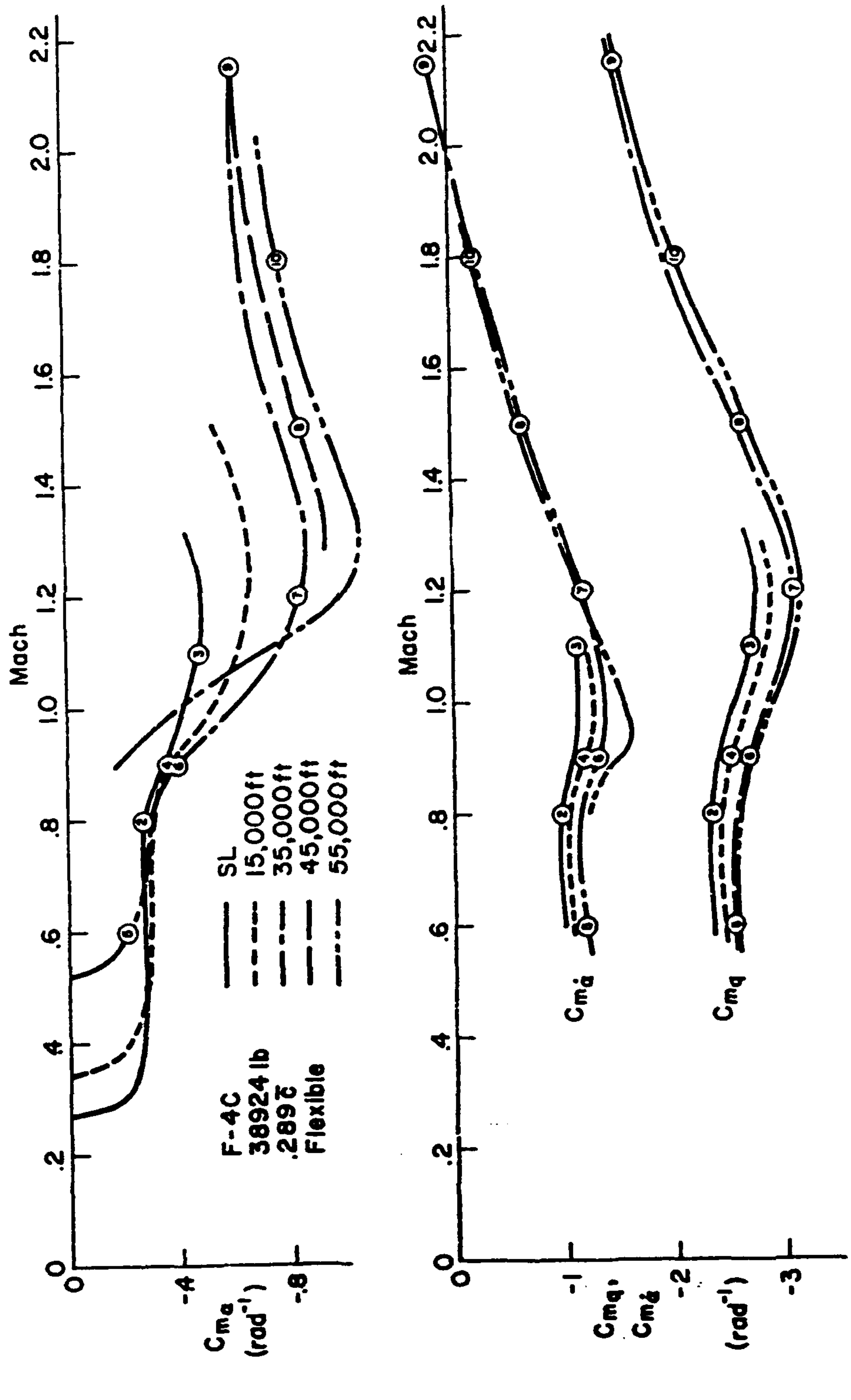


SL
15,000ft
35,000ft
45,000ft
55,000ft
F-4C
38924 lb
.289 c̄
α_o (deg)
δ_e (deg)
Mach

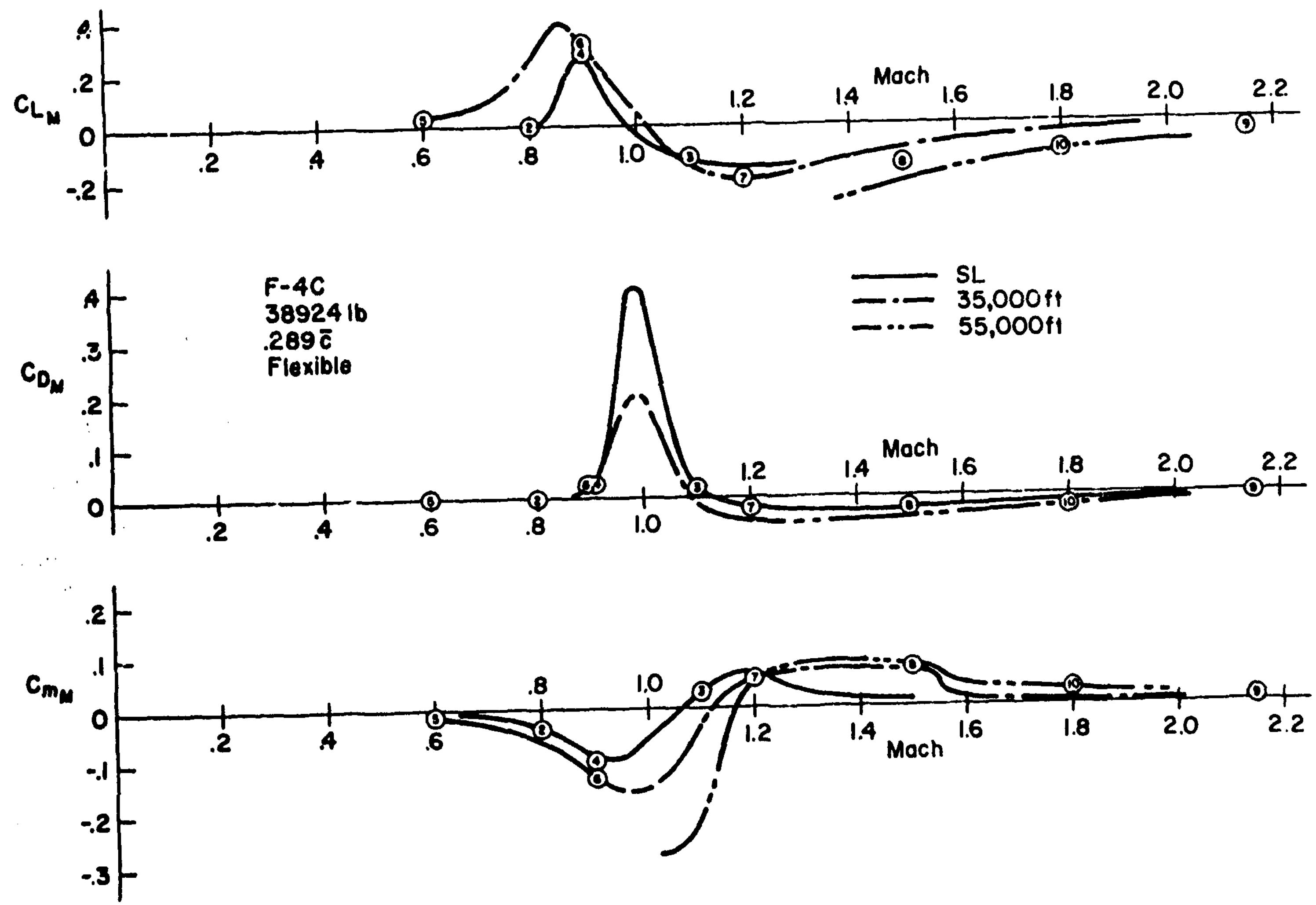


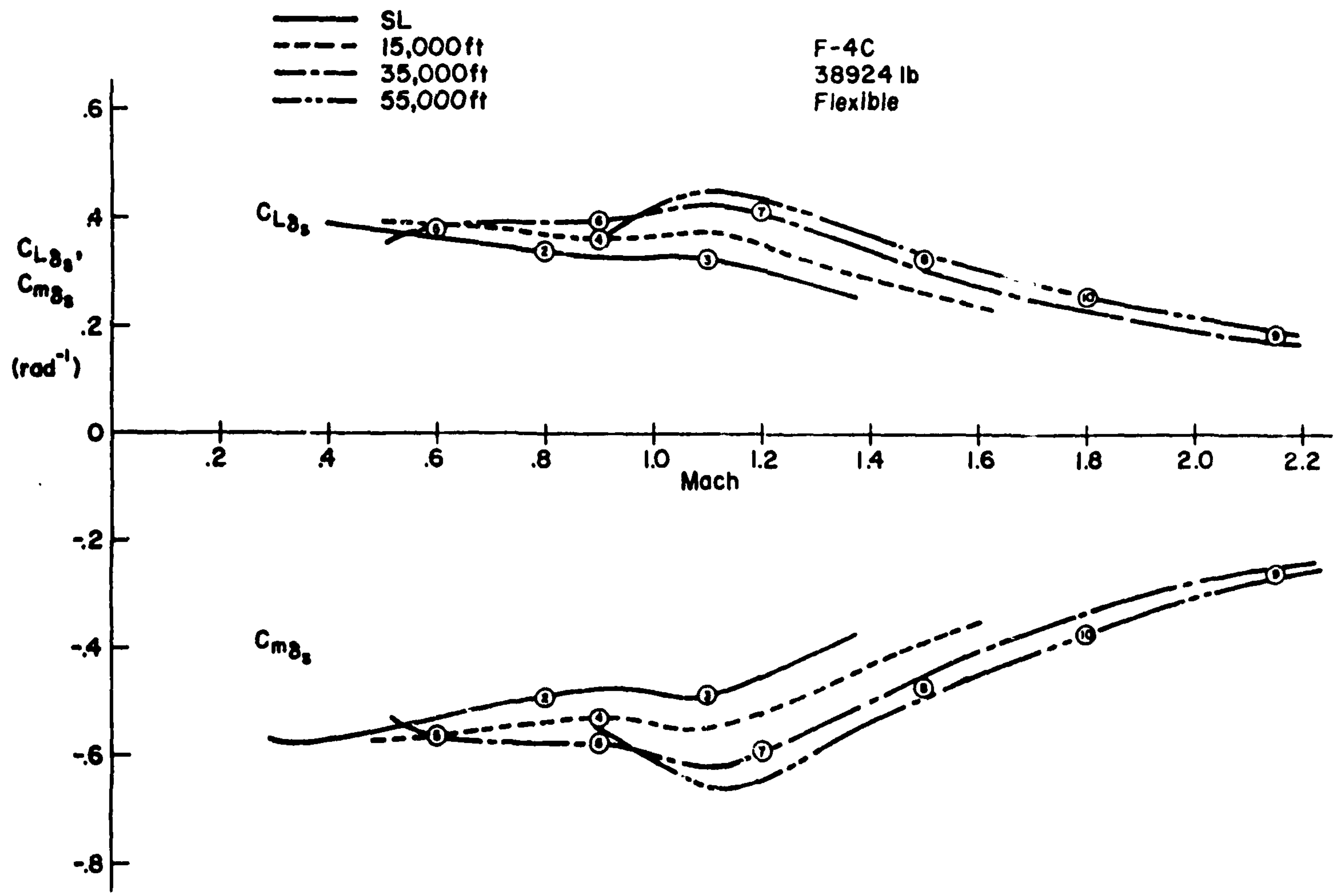
SL
15,000 ft
35,000 ft
45,000 ft
55,000 ft
F-4C
38924 lb
$C_{L_{MAX}}$
Zero Excess Thrust
Speed Restriction
C_L
C_D
$C_{D_{MIN}}$
Mach


SL
15,000ft
35,000ft
45,000ft
55,000ft
F-4C
38924lb
Flexible
C_{L_α} (rad^{-1})
Mach
C_{D_α} (rad^{-1})
Mach

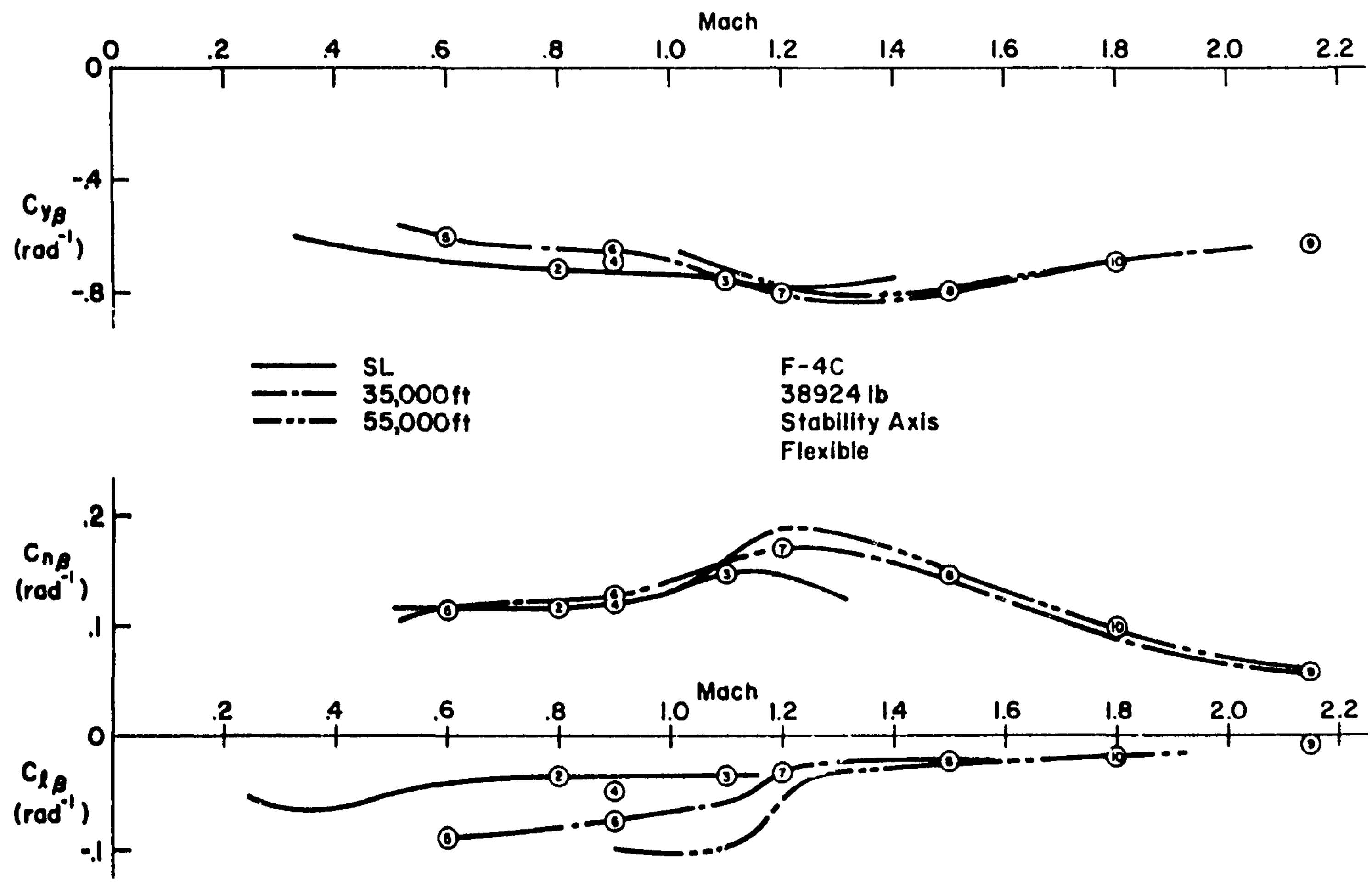


F-4C
38924 lb
.289c̄
Flexible
SL
15,000ft
35,000ft
45,000ft
55,000ft
Mach
Cmα
(rad⁻¹)
Cmα̇
Cmq
Cmq, Cmα̇
(rad⁻¹)

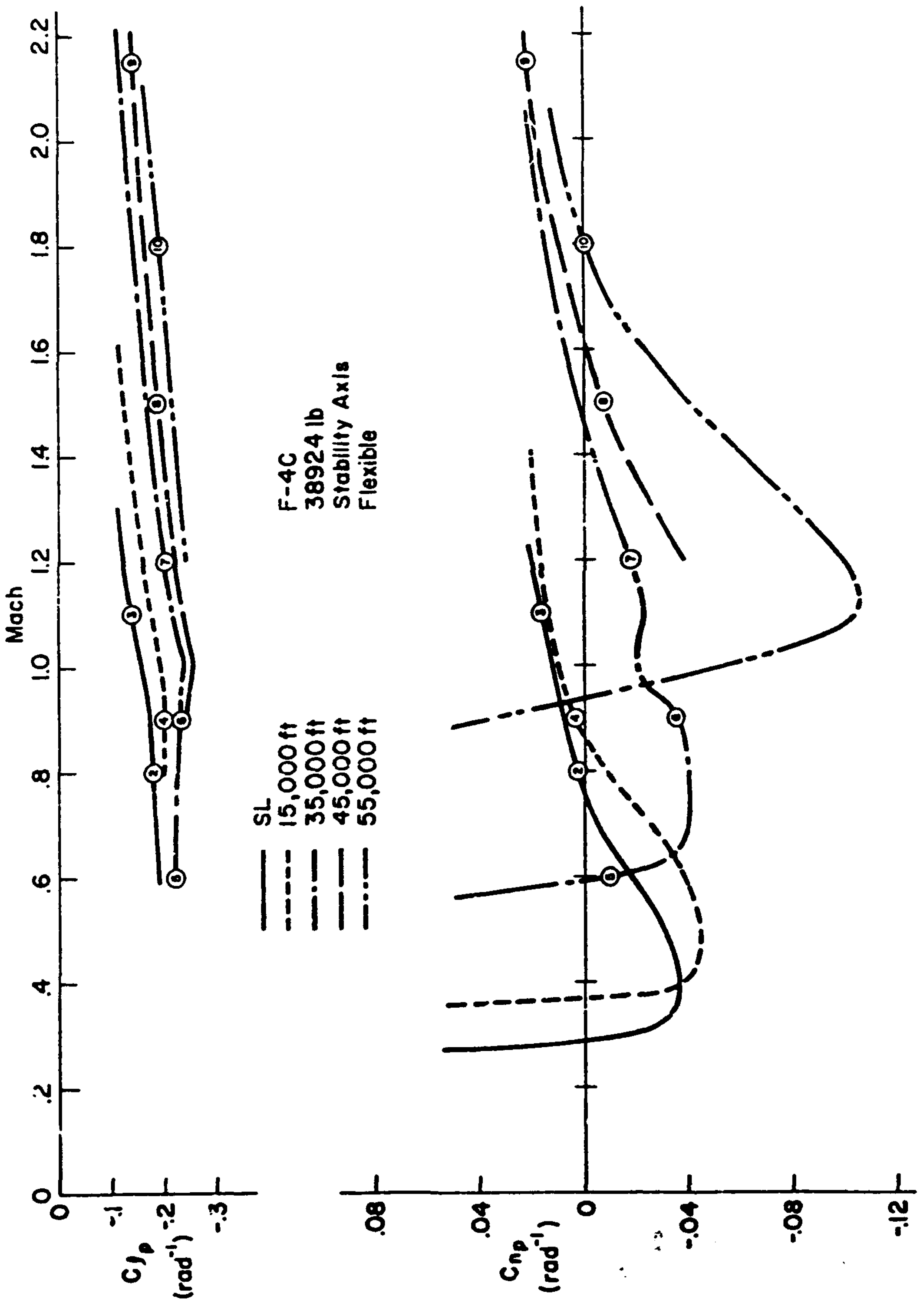

F-4C
38924 lb
.289 $\bar{c}$
Flexible
SL
35,000ft
55,000ft
C_{L_M}
C_{D_M}
C_{m_M}
Mach
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
.4
.3
.2
.1
0
-.1
-.2
-.3



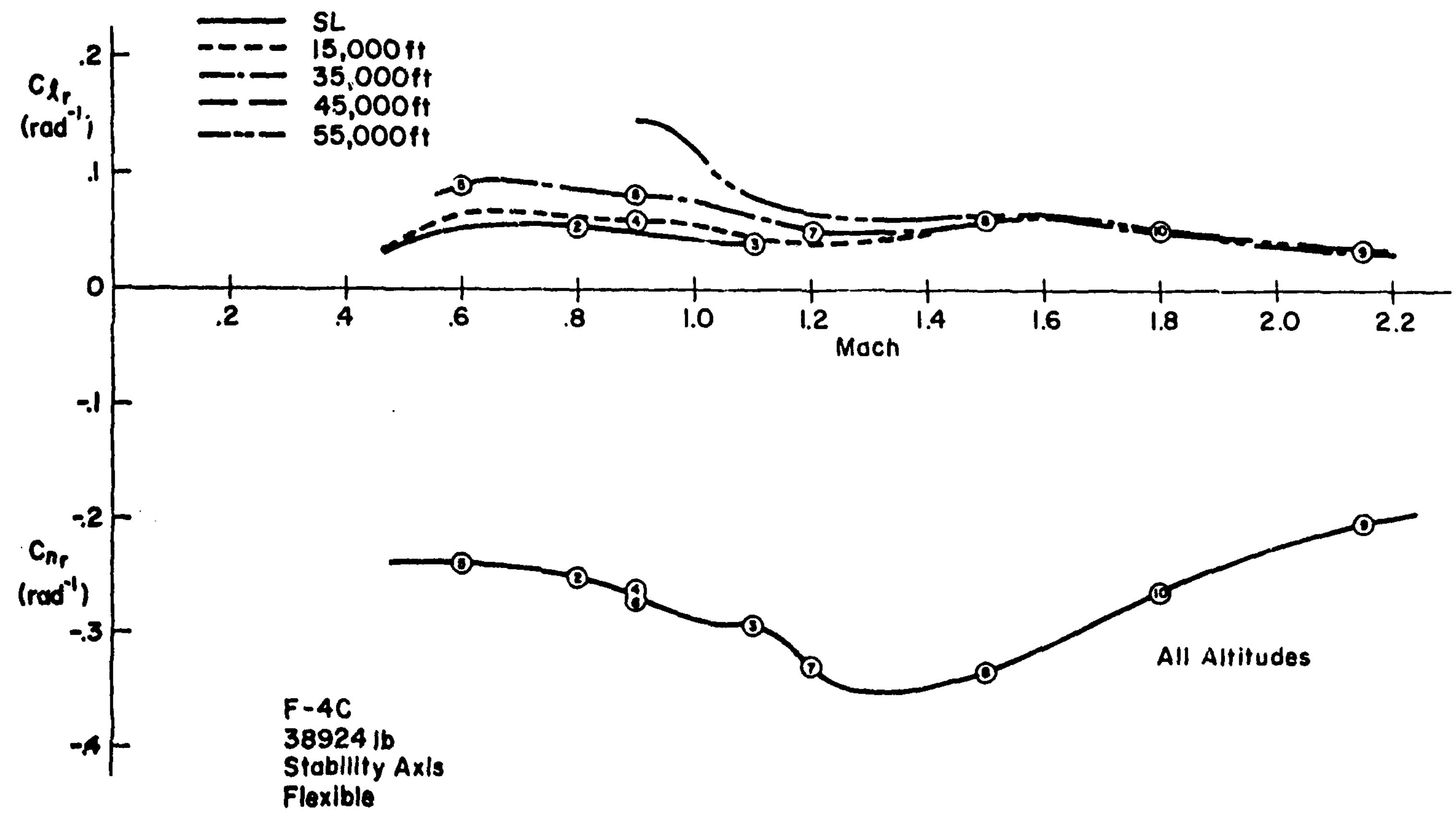
SL
15,000ft
35,000ft
55,000ft
F-4C
38924 lb
Flexible
$C_{L\delta_s}$
$C_{L\delta_s}$, $C_{m\delta_s}$ (rad^{-1})
$C_{m\delta_s}$
Mach

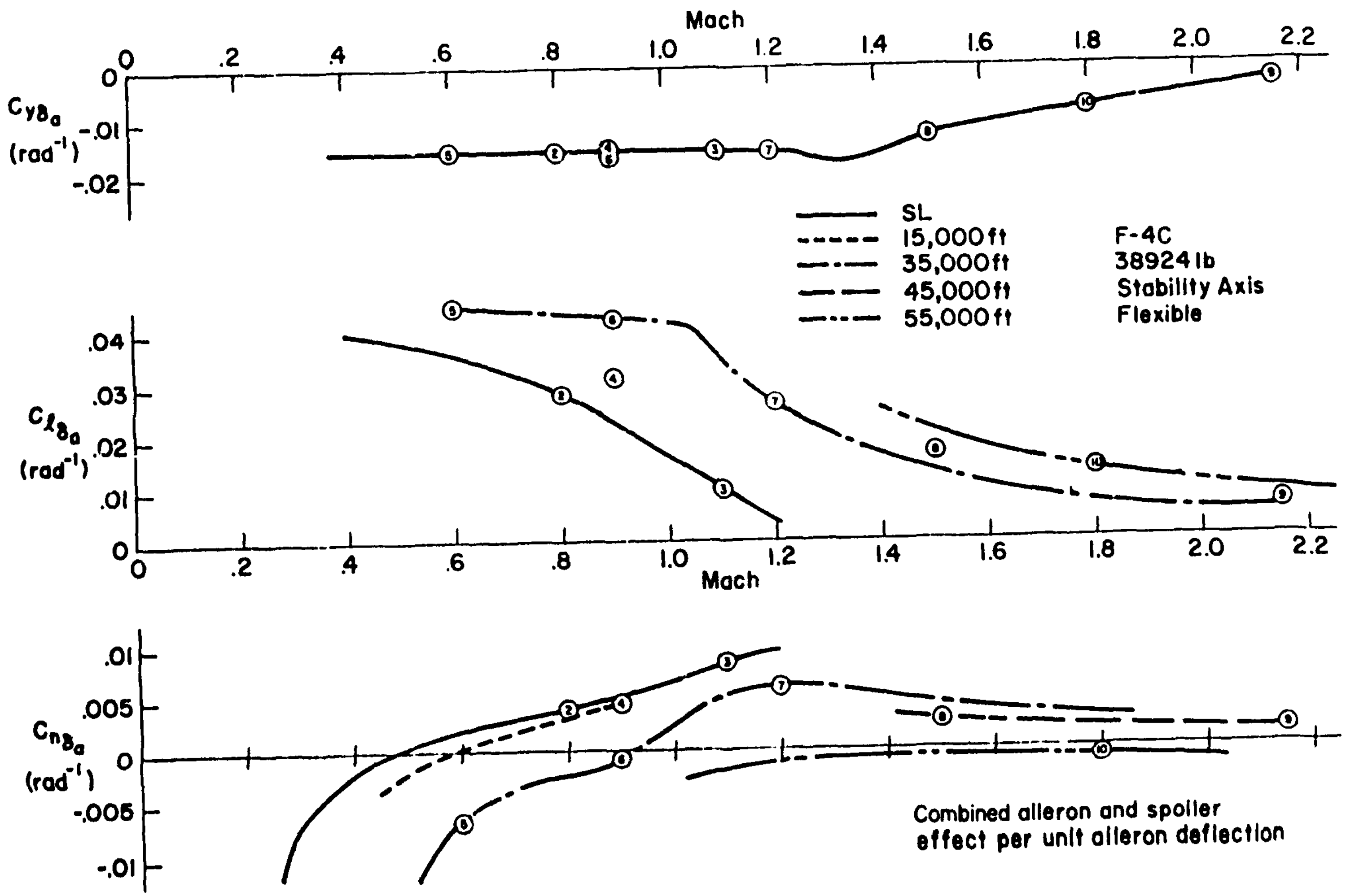


Mach
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
$C_{y\beta}$ (rad⁻¹)
0
-.4
-.8
SL
35,000ft
55,000ft
F-4C
38924 lb
Stability Axis
Flexible
$C_{n\beta}$ (rad⁻¹)
.2
.1
0
$C_{l\beta}$ (rad⁻¹)
-.1

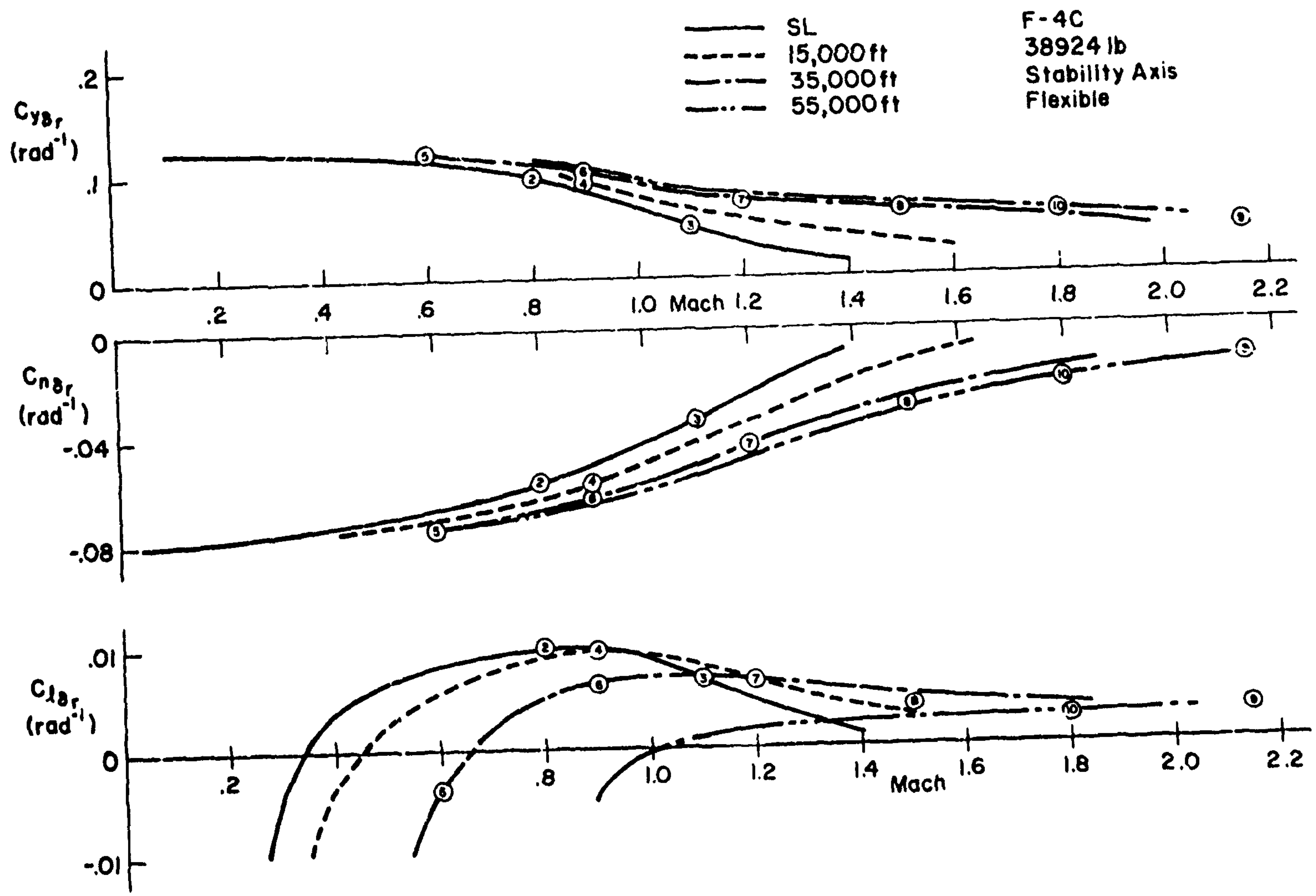


Mach
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
C_{l_p} (rad^{-1})
-.1
-.2
-.3
C_{n_p} (rad^{-1})
.08
.04
0
-.04
-.08
-.12
SL
15,000 ft
35,000 ft
45,000 ft
55,000 ft
F-4C
38924 lb
Stability Axis
Flexible


SL
15,000ft
35,000ft
45,000ft
55,000ft
C_{l_r} (rad^{-1})
C_{n_r} (rad^{-1})
.2
.1
0
-.1
-.2
-.3
-.4
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Mach
All Altitudes
F-4C
38924 lb
Stability Axis
Flexible



Mach
$C_{y\delta_a}$ (rad^{-1})
$C_{\ell\delta_a}$ (rad^{-1})
$C_{n\delta_a}$ (rad^{-1})
SL
15,000 ft
35,000 ft
45,000 ft
55,000 ft
F-4C
38924 lb
Stability Axis
Flexible
Combined aileron and spoiler effect per unit aileron deflection



SL
15,000 ft
35,000 ft
55,000 ft
F-4C
38924 lb
Stability Axis
Flexible
$C_{y\delta_r}$ (rad^{-1})
$C_{n\delta_r}$ (rad^{-1})
$C_{l\delta_r}$ (rad^{-1})
Mach

TABLE IV-2

F-4C DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

$s = 530$ sq ft, $b = 38.67$ ft, $\bar{c} = 16.04$ ft

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M(-)	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
VTO(FPS)	230.	893.	1228.	952.	584.	876.	1167.	1452.	2081.	1742.
VTO(KTAS)	136.	529.	728.	564.	346.	519.	692.	860.	1233.	1032.
VTO(KCAS)	136.	529.	728.	465.	199.	311.	432.	445.	632.	433.
W(LBS)	33197.	38925.	38925.	38925.	38925.	38925.	38925.	38925.	38925.	38925.
C.G.(MGC)	.291	.289	.289	.289	.289	.289	.289	.289	.289	.289
IX (SLUG-FT SQ)	23669.	25002.	25002.	25002.	25002.	25002.	25002.	25002.	25002.	25002.
IY (SLUG-FT SQ)	117506.	122193.	122193.	122193.	122193.	122193.	122193.	122193.	122193.	122193.
IZ (SLUG-FT SQ)	133730.	139767.	139767.	139767.	139767.	139767.	139767.	139767.	139767.	139767.
IXZ(SLUG-FT SQ)	1575.	2177.	2177.	2177.	2177.	2177.	2177.	2177.	2177.	2177.
EPSILON(DEG)	-.820	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09
Q(PSF)	62.6	948.	1792.	677.	126.	283.	503.	489.	1034.	434.
QC(PSF)	63.3	1109.	2397.	825.	138.	345.	703.	749.	1687.	706.
ALPHA(DEG)	11.7	.300	-.300	.500	9.40	2.60	1.60	2.60	1.40	3.30
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	16.3	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
LZP(FT)	-3.02	-2.81	-2.81	-2.81	-2.81	-2.81	-2.81	-2.81	-2.81	-2.81
ITH(DEG)	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25
XI(DEG)	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25
LTH(FT)	-.570	-.370	-.370	-.370	-.370	-.370	-.370	-.370	-.370	-.370

TABLE IV-3

F-4C LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.22	1.50	2.15	1.80
XU *	-.0417	-.0159	-.0677	-.0203	.000719	-.00796	-.0135	-.00679	-.0158	-.00528
ZU *	-.177	-.0645	.0226	-.134	-.0689	-.0876	.0125	.0110	-.000992	.000474
MU *	.000743	-.00161	.00329	-.00425	.000511	-.00239	.00292	.00341	.00128	.00175
XW	.130	.00706	-.0107	.00271	.00458	.0158	.00576	.00146	.00387	-.00501
ZW	-.452	-1.54	-2.11	-1.16	-.296	-.547	-.727	-.494	-.494	-.319
MW	-.00182	-.0199	-.0488	-.0179	-.00326	-.00911	-.0248	-.0198	-.0205	-.0133
ZWD	-.00305	-.00271	-.00326	-.00210	-.00104	-.00116	-.00106	-.000358	.977E-4	-.604E-4
ZQ	-2.48	-8.20	-8.72	-6.00	-1.84	-2.89	-4.09	-2.24	-1.27	-1.14
MWD	-.000642	-.000663	-.000729	-.000480	-.000244	-.000267	-.000247	-.840E-4	.259E-4	-.150E-4
MQ	-.317	-1.36	-2.20	-.993	-.307	-.487	-.745	-.488	-.404	-.284
XDS	5.98	.739	-1.32	.932	3.42	2.25	2.52	3.21	2.04	2.96
ZDS	-6.65	-141.	-251.	-107.	-20.7	-49.6	-90.4	-70.6	-83.6	-49.6
MDS	-1.46	-32.3	-61.1	-25.0	-4.90	-11.4	-20.7	-16.0	-16.1	-11.2
XDTH	.000965	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823
ZDTH	-.887E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4
MDTH	-.485E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5

TABLE IV-4

F-4C STABILIZER TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR										
Z(DET)1	.102	(-.0278)	.639	(-.0612)	.0928	(.0446)	.191	.156	.384	.175
W(DET)1	.191	(.0516)	.0542	(.0741)	.0774	(-.0456)	.0450	.0402	.0220	.0274
Z(DET)2	.607	.393	.324	.308	.259	.224	.162	.102	.0645	.0550
W(DET)2	.757	4.44	7.99	4.24	1.41	2.85	5.43	5.39	6.54	4.46
NUMERATORS										
N(U /DS)										
A(U)	5.97	.737	-1.31	.930	3.42	2.25	2.52	3.20	2.04	2.86
1/T(U)1	11.4	1.94	1.49	1.25	136.	201.	266.	.310	400.	.143
1/T(U)2	(.452)	5.35	-6.31	3.44	(.980)	(.787)	(.965)	.641	(.978)	.584
1/T(U)3	(.561)	157.	304.	218.	(.307)	(.643)	(.783)	328.	(.496)	394.
N(W /DS)										
A(W)	-6.62	-141.	-250.	-107.	-20.6	-49.5	-90.3	-70.6	-83.6	-49.6
1/T(W)1	49.3	204.	-.00320	222.	137.	202.	267.	328.	400.	304.
Z(W)1	.	.176	(.0711)	.169	.0121	.0964	.852	.290	.231	.184
W(W)1	.156	.0456	(299.)	.0627	.0627	.0532	.00729	.00911	.0109	.0114
N(THE/DS)										
A(THE)	-1.45	-32.2	-60.9	-24.5	-4.90	-11.4	-20.6	-16.0	-16.1	-11.2
1/T(THE)1	.104	.0162	.0678	.0208	-.000498	.0106	.0131	.00608	.0157	.00460
1/T(THE)2	.379	1.46	1.90	1.08	.232	.505	.618	.407	.388	.260
N(HD /DS)										
A(HD)	7.70	141.	250.	107.	20.9	49.6	90.3	70.6	83.6	49.7
1/T(HD)1	.00726	.0146	.0680	.0165	-.0245	.00335	.0123	.00489	.0151	.00307
1/T(HD)2	-4.21	17.0	-23.8	15.3	5.96	9.99	12.7	11.5	-12.4	-10.1
1/T(HD)3	4.27	-17.5	23.9	-15.7	-6.05	-10.2	-12.9	-11.5	12.5	10.1
N(AZP/DS)										
A(AZP)	17.0	382.	737.	298.	58.7	135.	244.	188.	177.	132.
1/T(AZP)1	-.0514	-.000207	.000137	-.000356	-.000194	-.00287	-.000776	-.00104	-.000385	-.00117
1/T(AZP)2	.0543	.0148	.0679	.0172	-.0243	.00618	.0131	.00590	.0154	.00419
Z(AZP)1	.121	.104	.0917	.0874	.0620	.0625	.0586	.0400	.0294	.0289
W(AZP)1	2.80	10.5	13.9	9.30	3.61	6.09	7.81	7.07	8.56	6.19

TABLE IV-5

F-4C THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR										
Z(DET)1	.102	(-.0378)	.639	(-.0612)	.0928	(.0446)	.191	.156	.36[illegible]	.175
W(DET)1	.191	(.0516)	.0542	(.0741)	.0774	(-.0456)	.0450	.0402	.0720	.0274
Z(DET)2	.607	.393	.324	.308	.259	.224	.162	.102	.0645	.0650
W(DET)2	.757	4.44	7.99	4.24	1.41	2.85	5.43	5.39	6.54	4.84
NUMERATORS										
N(U /DTH)										
A(U)	.000965	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823
1/T(U)1	.109	.00607	.00176	.00435	.00376	.00295	-.000327	-.000995	-.000421	-.00113
Z(U)1	.694	.393	.322	.306	.371	.244	.173	.125	.0788	.104
W(U)1	.732	4.45	8.00	4.26	1.46	2.88	5.43	5.38	6.54	4.84
N(W /DTH)										
A(W)	-.878E-4	-.754E-4	-.754E-4	-.755E-4	-.754E-4	-.755E-4	-.755E-4	-.756E-4	-.756E-4	-.756E-4
1/T(W)1	14.3	.00167	-.00175	.000503	24.0	-.000110	-.00303	-.00281	-.00193	-.00279
1/T(W)2	(-.123)	.458	-.788	1.18	(-.807)	.658	-.756	-.897	-.327	-.441
1/T(W)3	(.161)	37.0	51.7	35.1	(.0746)	35.6	47.9	59.2	84.0	70.3
N(THE/DTH)										
A(THE)	-.467E-5	-.298E-5	-.298E-5	-.299E-5	-.298E-5	-.300E-5	-.300E-5	-.302E-5	-.303E-5	-.303E-5
1/T(THE)1	-.192	.283	-1.21	.517	-.289	.178	.450	.321	.282	.215
1/T(THE)2	.480	1.23	1.28	1.38	.358	.800	-1.13	-1.24	-.630	-.700
N(HD /DTH)										
A(HD)	.000282	.797E-4	.711E-4	.826E-4	.000209	.000113	.985E-4	.000113	.957E-4	.000123
1/T(HD)1	1.09	.341	-1.86	1.05	1.45	.681	2.53	1.43	1.08	.655
Z(HD)1	-.552	(-4.91)	(-4.80)	(-4.11)	-.367	(-1.86)	-.293	-.122	-.0978	-.0393
W(HD)1	.516	(6.88)	(8.90)	(5.67)	.793	(2.62)	2.68	3.31	3.29	3.15
N(AZP/DTH)										
A(AZP)	-.120E-4	-.272E-4	-.272E-4	-.270E-4	-.272E-4	-.264E-4	-.268E-4	-.267E-4	-.261E-4	-.266E-4
1/T(AZP)1	-.0214	-.000189	.000137	-.000256	-.00872	-.00168	-.000768	-.00100	-.000377	-.00106
1/T(AZP)2	16.5	.332	-2.06	.996	-.805	.451	6.65	5.07	3.61	3.30
Z(AZP)1	-.984	(-8.60)	(-6.63)	(-7.34)	(-1.59)	(-4.60)	-.536	-.316	-.294	-.275
W(AZP)1	.015	(11.8)	(15.3)	(10.2)	(5.35)	(6.67)	3.16	3.60	3.43	3.01

TABLE IV-6

F-4C STICK FORCE TRANSFER FUNCT[illegible] FACTORS

SAS Off — Bobweight Loop [illegible]sed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	[illegible]	6	7	8	9	10
H	SL	SL	SL	15 K	[illegible] K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	[illegible]	.900	1.23	1.50	2.15	1.80
DENOMINATOR										
1/T(DET)1	20.8	-.0271	26.6	-.0445	2[illegible]	-.0335	24.5	1.40	3.10	1.33
1/T(DET)2		.0412		.0585		.0343		23.2	21.1	27.2
Z(DET)1	.146	(25.3)	.760	(25.0)	-.[illegible]	(23.51)	.205	.159	.411	.109
W(DET)1	.0881		.0454		.[illegible]		.0389	.0221	.0192	.0218
Z(DET)2	.271	.277	.263	.215	.1[illegible]	.155	.148	.133	.102	.101
W(DET)2	1.15	4.91	7.90	4.60	1.[illegible]	3.09	5.12	5.07	6.36	4.63
Z(DET)3	.427	.0192	.000438	.0253	.1[illegible]	.0751	.0302	.109	.174	.137
W(DET)3	6.01	29.1	38.9	24.6	11[illegible]	16.5	22.1	22.4	34.5	22.5
NUMERATORS										
[illegible] /FST)										
A(U)	-190.	-23.4	41.7	-29.6	-1[illegible]	-7[illegible].5	-80.2	-102.	-64.9	-90.9
1/T(U)1	11.4	1.95	1.49	1.25	1[illegible]	201.	266.	.310	11.1	.143
1/T(U)2	(.452)	5.35	-6.31	3.44	([illegible])	(.787)	(.965)	.661	400.	.594
1/T(U)3	(.561)	197.	304.	218.	([illegible])	(.643)	(.784)	4.22	(.970)	4.42
1/T(U)4								328.	(.400)	904.
N(W /FST)										
A(W)	210.	4476.	7961.	3388.	6[illegible]	1573.	2869.	2242.	2656.	1574.
1/T(W)1	49.3	204.	-.00320	222.	1[illegible]	202.	267.	4.22	11.1	4.42
1/T(W)2			.0711					328.	400.	394.
Z(W)1	.151	.176	(299.)	.165	[illegible]	.0964	.852	.290	.741	.184
W(W)1	.156	.0456		.0527	[illegible]	.0532	.00729	.00911	.0105	.0114
N(THE/FST)										
A(THE)	46.2	1024.	1936.	792.	1[illegible]	363.	656.	508.	511.	357.
1/T(THE)1	.104	.0162	.0678	.0208	-.0[illegible]8	.0105	.0131	.00608	.0157	.00460
1/T(THE)2	.379	1.45	1.90	1.08	[illegible]	.505	.618	.407	.389	.260
1/T(THE)3								4.22	11.1	4.42
N(HD /FST)										
A(HD)	-245.	-4476.	-7961.	-2388.	-66[illegible]	-1575.	-2670.	-2245.	-2657.	-1579.
1/T(HD)1	.00726	.0146	.0680	.0165	-.[illegible]	.00335	.0123	.00489	.0151	.00307
1/T(HD)2	-4.21	17.0	-23.8	15.3	[illegible]	9.99	12.7	4.22	11.1	4.42
1/T(HD)3	4.27	-17.5	23.9	-15.7	-[illegible]	-10.2	-12.9	11.5	-12.4	-10.1
1/T(HD)4								-11.5	12.5	10.1

TABLE IV-6 (Concluded)

N(AZP/FST)										
A(AZP)	-540.	-12129.	-23430.	-5456.	-186[illegible].	-4306.	-7765.	-5989.	-5624.	-4209.
1/T(AZP)1	-.0514	-.000207	.000137	-.000356	-.00194	-.00287	-.000776	-.00104	-.000385	-.00117
1/T(AZP)2	.0543	.0148	.0679	.0172	-.02[illegible]	.00618	.0131	.00590	.0154	.00419
1/T(AZP)3								4.22	11.1	4.42
Z(AZP)1	.121	.104	.0917	.0876	.0620	.0625	.0586	.0400	.0294	.0280
W(AZP)1	2.80	10.5	13.9	9.30	3.61	6.09	7.81	7.07	8.56	6.19

TABLE IV-7

F-4C THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.22	1.50	2.15	1.50
DENOMINATOR										
1/T(DET)1	20.8	-.0271	26.6	-.0445	22.0	-.0335	24.5	1.49	3.10	1.35
1/T(DET)2		.0412		.0589		.0343		23.2	21.1	22.2
Z(DET)1	.146	(25.3)	.760	(25.0)	-.0455	(23.5)	.205	.159	.431	.169
W(DET)1	.0881		.0454		.0540		.0289	.0291	.0192	.0218
Z(DET)2	.271	.277	.263	.215	.166	.155	.148	.138	.102	.101
W(DET)2	1.15	4.91	7.90	4.60	1.67	3.09	5.12	5.07	6.36	4.63
Z(DET)3	.427	.0192	.000438	.0252	.167	.0751	.0302	.109	.174	.137
W(DET)3	6.01	29.1	39.9	24.6	11.4	16.5	22.1	22.4	34.5	22.5
NUMERATORS										
N(U /DTH)										
A(U)	.000965	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823
1/T(U)1	.00561	.00339	.00128	.00241	-.00271	.000946	-.000438	-.000299	-.000410	-.00110
1/T(U)2	20.8	25.3	26.6	25.0	22.0	23.5	24.5	1.49	3.10	1.36
1/T(U)3								23.2	21.1	22.2
Z(U)1	.318	.277	.262	.220	.247	.172	.158	.159	.117	.138
W(U)1	1.19	4.92	7.91	4.62	1.71	3.11	5.12	5.05	6.36	4.62
Z(U)2	.432	.0192	.000420	.0254	.169	.0755	.0305	.109	.174	.137
W(U)2	6.02	29.1	38.9	24.6	11.4	16.5	22.1	22.5	34.5	22.5
N(W /DTH)										
A(W)	-.878E-4	-.754E-4	-.754E-4	-.755E-4	-.754E-4	-.755E-4	-.755E-4	-.756E-4	-.756E-4	-.756E-4
1/T(W)1	.0248	.00116	-.00172	.000299	18.4	-.000597	-.00304	-.00293	-.00215	-.00304
1/T(W)2	.396	.518	-.651	1.26	26.3	.744	-.587	-.537	-.222	-.277
1/T(W)3	12.7	20.7	21.9	20.9	(.0331)	20.4	21.4	1.21	2.92	1.21
1/T(W)4	21.3	39.3	53.4	40.9	(.0514)	36.0	48.8	21.3	20.5	21.0
1/T(W)5								59.6	84.2	73.5
Z(W)1	.520	.0458	.0242	.0557	.214	.121	.0722	.146	.188	.167
W(W)1	5.25	29.0	38.7	24.3	10.9	16.0	21.5	22.2	34.6	22.4
N(THE/DTH)										
A(THE)	-.467E-5	-.298E-5	-.296E-5	-.299E-5	-.298E-5	-.300E-5	-.300E-5	-.302E-5	-.303E-5	-.303E-5
1/T(THE)1	-.0923	.250	-1.10	.391	-.185	.127	.420	.273	.266	.199
1/T(THE)2	.901	1.11	1.13	1.43	.444	.865	-.949	-.887	-.516	-.516
1/T(THE)3	20.3	23.2	23.8	23.1	21.2	22.2	22.8	1.28	2.95	1.24
1/T(THE)4								21.9	20.6	21.3
Z(THE)1	.478	.0457	.0246	.0551	.197	.110	.0643	.146	.184	.145
W(THE)1	5.04	28.4	38.0	23.8	10.7	15.7	21.1	21.9	34.9	22.2

TABLE IV-7 (Concluded)

N(HD /DTH)										
A(HD)	.000282	.797E-4	.711E-4	.826E-4	.000209	.000113	.985E-4	.000113	.957E-4	.000123
1/T(HD)1	1.12	.349	-1.84	1.10	.734	-1.33	1.94	.527	.785	.363
1/T(HD)2	20.8	-4.32	-4.26	-3.53	22.0	23.4	24.4	2.15	3.39	1.47
1/T(HD)3		5.45	7.06	4.38				23.1	21.1	22.2
Z(HD)1	-.0630	(25.1)	(26.5)	(24.8)	-.0241	.941	-.245	-.0570	-.0494	.00928
W(HD)1	.484				.906	1.30	2.53	3.11	3.13	4.00
Z(HD)2	.435	.0241	.00513	.0308	.169	.0800	.0351	.114	.177	.141
W(HD)2	5.91	29.0	38.7	24.4	11.3	16.3	21.9	22.4	34.5	22.5
N(AZP/DTH)										
A(AZP)	-.120E-4	-.272E-4	-.272E-4	-.270E-4	-.272E-4	-.269E-4	-.268E-4	-.267E-4	-.265E-4	-.266E-4
1/T(AZP)1	-.0214	-.000189	.000137	-.000256	-.00872	-.00168	-.000758	-.00100	-.000377	-.00106
1/T(AZP)2	7.89	.331	-2.13	.991	3.78	.448	4.63	.867	1.94	.895
1/T(AZP)3	24.9	-7.43	-5.54	-6.15	23.1	-3.74	27.0	4.83	5.12	3.53
1/T(AZP)4		8.15	9.66	7.01		4.62		25.1	21.9	23.5
Z(AZP)1	-.847	(28.4)	(31.7)	(27.7)	-.969	(25.2)	-.532	-.281	-.258	-.235
W(AZP)1	.709				1.02		2.81	3.06	3.01	2.60
Z(AZP)2	.622	-.00375	-.0192	.000280	.151	.0481	.00588	.0768	.157	.108
W(AZP)2	7.20	25.9	39.9	25.4	12.1	17.2	23.2	23.3	[illegible]	23.0

TABLE IV-c

F-4C STABILIZER TRANSFER [illegible]ION FACTORS

SAS On — Bobweight L[illegible] Open

(BODY AXIS SYS[illegible]

F/C #	1	2	3	4	[illegible]	6	7	8	9	10
H	SL	SL	SL	15 K	[illegible] K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	[illegible]	.900	1.20	1.50	2.15	1.9[illegible]
DENOMINATOR										
1/T(DET)1	1.24	-.0579	.858	-.0607	[illegible]	.0447	1.05	.883	1.04	.924
1/T(DET)2	15.8	.0570	6.40	.0746	[illegible]	-.0454	16.1	1.06	2.34	1.06
1/T(DET)3		.851		.574		1.18		17.7	17.4	18.1
ζ(DET)1	.0668	(4.44)	.637	(14.2)	[illegible]90	(17.9)	.189	.155	.384	.175
ω(DET)1	.189		.0542		[illegible]75		.0450	.0402	.0220	.0274
ζ(DET)2	.672	.540	.620	.824	[illegible]	.568	.477	.379	.250	.247
ω(DET)2	.690	10.2	15.3	5.10	[illegible]	2.77	5.90	5.64	6.83	4.93
ζ(DET)3	.584	.103	.0760	.125	[illegible]	.194	.141	.210	.204	.209
ω(DET)3	4.83	27.4	37.1	22.6	[illegible]	14.5	20.0	21.4	34.5	21.9
NUMERATORS										
N(L /DS)										
A(U)	5.97	.737	-1.31	.930	[illegible]	2.25	2.52	3.20	2.04	2.96
1/T(U)1	1.00	1.00	1.00	1.00	[illegible]	1.00	1.00	.310	1.00	.143
1/T(U)2	11.4	1.94	1.49	1.25	[illegible]	20.0	20.0	.641	2.34	.584
1/T(U)3	20.0	5.35	-6.31	3.44	[illegible]	201.	266.	.883	20.0	.924
1/T(U)4	(.452)	20.0	20.0	20.0	([illegible])	(.787)	(.965)	1.00	400.	1.00
1/T(U)5	(.561)	157.	304.	218.	([illegible])	(.643)	(.783)	20.0	(.978)	20.0
1/T(U)6								328.	(.496)	394.
ζ(U)1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.194	.141	.210	.208	.209
ω(U)1	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N(W /DS)										
[illegible]	-6.62	-141.	-250.	-107.	[illegible]	-49.5	-90.3	-70.6	-83.6	-49.6
1/T(W)1	1.00	1.00	-.00320	1.00	[illegible]	1.00	1.00	.883	1.00	.924
1/T(W)2	20.0	20.0	.0711	20.0	[illegible]	20.0	20.0	1.00	2.34	1.00
1/T(W)3	49.3	204.	1.00	222.	[illegible]	202.	267.	20.0	20.0	20.0
1/T(W)4			20.0					328.	400.	394.
ζ(W)1	.151	.176	(299.)	.165	[illegible].21	.0964	.852	.290	.731	.184
ω(W)1	.156	.0456		.0627	[illegible]27	.0532	.00729	.00911	.0106	.0114
ζ(W)2	.584	.103	.0760	.125	[illegible]	.194	.141	.210	.208	.209
ω(W)2	4.83	27.4	37.1	22.6	[illegible]	14.5	20.0	21.4	34.5	21.9

TABLE IV-8 (Concluded)

N(THE/DS)										
A(THE)	-1.45	-32.2	-60.9	-24.9	-4.90	-11.4	-20.6	-16.0	-16.1	-11.2
1/T(THE)1	.304	.0162	.0676	.0206	-.000449	.0106	.0131	.00108	.0157	.00460
1/T(THE)2	.379	1.00	1.00	1.00	.282	.505	.618	.407	.388	.260
1/T(THE)3	1.00	1.46	1.90	1.08	1.00	1.00	1.00	.883	1.00	.924
1/T(THE)4	20.0	20.0	20.0	20.0	20.0	20.0	20.0	1.00	2.34	1.00
1/T(THE)5								20.0	20.0	20.0
Z(THE)1	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(THE)1	4.83	27.4	37.1	22.6	9.82	14.5	20.0	21.4	34.5	21.9
N(HD /DS)										
A(HD)	7.70	141.	250.	107.	20.9	49.6	90.3	70.6	63.6	49.7
1/T(HD)1	.00726	.0146	.0680	.0165	-.0245	.00335	.0123	.00489	.0151	.00307
1/T(HD)2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.093	1.00	.924
1/T(HD)3	-4.21	17.0	20.0	15.3	5.96	9.99	12.7	1.00	2.34	1.00
1/T(HD)4	4.27	-17.5	-24.8	-15.7	-6.05	-10.2	-12.9	11.5	-12.4	-10.1
1/T(HD)5	20.0	20.0	23.9	20.0	20.0	20.0	20.0	-11.5	12.5	10.1
1/T(HD)6								20.0	20.0	20.0
Z(HD)1	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(HD)1	4.83	27.4	37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9
N(AZP/DS)										
A(AZP)	17.0	362.	737.	258.	58.7	135.	244.	188.	177.	132.
1/T(AZP)1	-.0514	-.000207	.000137	-.000356	-.00194	-.00267	-.000775	-.00104	-.000385	-.00117
1/T(AZP)2	.0543	.0148	.0675	.0172	-.0243	.00618	.0131	.00590	.0154	.00419
1/T(AZP)3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.683	1.00	.924
1/T(AZP)4	20.0	20.0	20.0	20.0	20.0	20.0	20.0	1.00	2.34	1.00
1/T(AZP)5								20.0	20.0	20.0
Z(AZP)1	.121	.104	.0917	.0876	.0620	.0625	.0585	.0400	.0294	.0280
W(AZP)1	2.80	10.5	13.9	9.30	3.51	6.09	7.81	7.07	8.55	6.19
Z(AZP)2	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(AZP)2	4.83	27.4	37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9

TABLE IV-9

F-4C THRUST TRANSFER FUNCTION FACTORS

SAS On — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.6[illegible]	.900	1.20	1.5[illegible]	2.15	1.8[illegible]
DENOMINATOR										
1/T(DET)1	1.24	-.0375	.858	-.0507	1.44	.0447	1.05	.883	1.04	.924
1/T(DET)2	19.8	.0520	6.40	.0746	19.[illegible]	-.0454	16.1	1.04	2.34	1.05
1/T(DET)3		.651		.974		1.18		17.2	17.4	18.1
Z(DET)1	.0868	(4.44)	.632	(14.2)	.06[illegible]	(17.9)	.189	.155	.384	.175
W(DET)1	.189		.0542		.0775		.0450	.0402	.0220	.0275
Z(DET)2	.672	.940	.620	.824	.464	.568	.477	.339	.250	.247
W(DET)2	.690	10.2	15.3	5.10	1.20	2.77	5.90	5.64	6.88	4.93
Z(DET)3	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(DET)3	4.83	27.4	37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9
NUMERATORS										
N(U /DTH)										
A(U)	.000965	.000823	.000823	.000823	.000[illegible]	.000823	.000823	.000823	.000923	.000823
1/T(U)1	.112	.00608	.00177	.00439	.0037[illegible]	.00295	-.000327	-.000995	-.000421	-.00113
1/T(U)2	1.31	.851	.858	.574	1.55	1.18	1.05	.883	1.04	.974
1/T(U)3	15.8	4.45	6.43	14.2	15.2	17.9	16.0	1.06	2.34	1.06
1/T(U)4								17.2	17.3	18.1
Z(U)1	.738	.939	.615	.825	.573	.589	.490	.365	.265	.289
W(U)1	.637	10.2	15.2	5.11	1.20	2.80	5.91	5.64	6.89	4.93
Z(U)2	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(U)2	4.63	27.4	37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9
N(W /DTH)										
A(W)	-.678E-4	-.754E-4	-.754E-4	-.754E-4	-.754E-4	-.755E-4	-.755E-4	-.756E-4	-.756E-4	-.756E-4
1/T(W)1	1.02	.00167	-.00175	.00503	.998	-.000110	-.00300	-.00281	-.00193	-.00279
1/T(W)2	14.6	.429	-.746	.647	(-.798)	.630	-.740	-.883	-.324	-.458
1/T(W)3	19.4	.959	.918	1.22	(.0739)	1.00	.970	.883	.924	.924
1/T(W)4	(-.120)	(.103)	26.0	24.3	([illegible])	22.2	22.0	.983	2.34	.987
1/T(W)5	(.159)	(27.4)	45.7	34.5	(5.62)	33.5	45.9	21.0	20.6	20.6
1/T(W)6								58.2	83.4	69.8
Z(W)1	.584	.994	.0760	.125	.99[illegible]	.194	.141	.210	.208	.209
W(W)1	4.83	26.7	37.1	22.6	22.[illegible]	14.5	20.0	21.4	34.5	21.9

TABLE IV-9 (Concluded)

N(THE/DTH)										
A(THE)	-.467E-5	-.298E-5	-.298E-5	-.299E-5	-.298E-5	-.300E-5	-.300E-5	-.302E-5	-.303E-5	-.303E-5
1/T(THE)1	-.192	.283	1.00	.517	-.289	.178	.450	.321	.282	.215
1/T(THE)2	.480	1.00	-1.21	1.00	.358	.800	1.00	.883	-.630	-.700
1/T(THE)3	1.00	1.23	1.28	1.36	1.00	1.00	-1.13	1.00	1.00	.924
1/T(THE)4	20.0	20.0	20.0	20.0	20.0	20.0	20.0	-1.24	2.34	1.00
1/T(THE)5								20.0	20.0	20.0
Z(THE)1	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(THE)1	4.63	27.4	37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9
N(HD /DTH)										
A(HD)	.000282	.797E-4	.711E-4	.876E-4	.000209	.000113	.985E-4	.000113	.957E-4	.000123
1/T(HD)1	.998	.331	.538	.775	.840	.614	.897	.851	.765	.598
1/T(HD)2	2.06	.572	(-.542)	1.26	2.25	.907	5.34	.383	2.14	.924
1/T(HD)3	19.8	-3.83	(2.51)	-3.27	19.2	-1.52	16.4	2.73	2.34	1.44
1/T(HD)4				11.2		4.30		17.4	17.6	18.3
Z(HD)1	-.523	.946	.825	(13.7)	-.311	(18.1)	-.148	.109	.160	.188
W(HD)1	.497	13.7	16.4		.710		2.15	2.78	2.82	2.88
Z(HD)2	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(HD)2	4.83	27.4	37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9
N(AZP/DTH)										
A(AZP)	-.120E-4	-.272E-4	-.272E-4	-.270E-4	-.272E-4	-.269E-4	-.268E-4	-.267E-4	-.265E-4	-.265E-4
1/T(AZP)1	-.0214	-.000189	.000137	-.000256	-.0872	-.00168	-.000758	-.00100	-.000377	-.00106
1/T(AZP)2	1.04	.324	.940	.766	.994	.426	.928	.883	.906	.902
1/T(AZP)3		.568		1.24	7.36	1.00		.933	2.34	.924
Z(AZP)1	-.922	(-5.98)	-.880	(-5.22)	(17.5)	(-3.55)	-.392	-.177	-.115	-.133
W(AZP)1	.780		2.76				2.44	2.75	2.47	2.30
Z(AZP)2	.584	.770	.651	.806	-.545	.951	.814	.873	.897	.996
W(AZP)2	4.83	19.0	24.2	17.4	1.03	13.5	15.5	13.6	12.4	11.2
Z(AZP)3	.975	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(AZP)3	18.6	27.4	37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9

TABLE IV-[illegible]

F-4C STICK FORCE TRANSFER FUNCTION FACTORS

SAS On — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.90
DENOMINATOR										
1/T(DET)1	1.05	-.0270	.902	-.0443	1.14	-.0335	1.04	.990	1.02	.951
1/T(DET)2	20.6	.0413	17.9	.0550	21.4	.0344	22.2	1.68	3.14	1.50
1/T(DET)3		.924		.938		1.07		21.1	18.5	20.7
Z(DET)1	.143	(21.2)	.755	(22.1)	.0469	(22.2)	.204	.159	.431	.165
W(DET)1	.0880		.0454		.0540		.0369	.0291	.0192	.0218
Z(DET)2	.313	.627	.657	.504	.294	.342	.357	.337	.285	.263
W(DET)2	1.12	5.53	10.1	4.87	1.56	3.03	5.22	4.98	6.46	4.56
Z(DET)3	.431	.0181	-.00197	.0256	.170	.0761	.0316	.106	.173	.135
W(DET)3	6.06	29.4	39.2	24.5	11.5	16.7	22.4	22.6	34.5	22.6
NUMERATORS										
N(U /FST)										
A(U)	-190.	-23.4	41.7	-29.6	-109.	-71.5	-80.2	-102.	-64.9	-90.9
1/T(U)1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.310	1.00	.141
1/T(U)2	11.4	1.94	1.49	1.25	136.	201.	266.	.641	[illegible]	.544
1/T(U)3	(.452)	5.35	-6.31	3.44	(.980)	(.787)	(.965)	1.00	[illegible]	1.00
1/T(U)4	(.561)	197.	304.	218.	(.307)	(.643)	([illegible])	4.22	(.0780)	[illegible]
1/T(U)5								328.	(.496)	394.
N(h /FST)										
A(h)	210.	4476.	7961.	3388.	656.	1573.	2869.	2242.	2656.	1576.
1/T(h)1	1.00	1.00	-.00320	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1/T(h)2	49.3	204.	.0711	222.	137.	202.	267.	4.22	11.1	4.42
1/T(h)3			1.00					328.	430.	394.
Z(h)1	.151	.176	(299.)	.165	.0121	.0964	.352	.290	.731	.184
W(h)1	.156	.0456		.0627	.0627	.0532	.00729	.00911	.0106	.0114

TABLE IV-10 (Concluded)

N(THE/FST)										
A(THE)	46.2	1024.	1936.	752.	156.	363.	656.	508.	511.	357.
1/T(THE)1	.104	.0162	.0678	.0208	-.000448	.0106	.0131	.00608	.0157	.00460
1/T(THE)2	.379	1.00	1.00	1.00	.282	.505	.618	.407	[illegible]	.260
1/T(THE)3	1.00	1.46	1.90	1.08	1.00	1.00	1.00	1.00	1.00	1.00
1/T(THE)4								4.22	11.1	4.42
N(HD /FST)										
A(HD)	-245.	-4476.	-7961.	-3388.	-665.	-1575.	-2870.	-2245.	-2657.	-1579.
1/T(HD)1	.00726	.0146	.0660	.0165	-.0245	.00335	.0123	.00489	.0151	.00307
1/T(HD)2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1/T(HD)3	.21	17.0	-23.0	15.3	5.96	9.95	12.7	4.22	11.1	4.42
1/T(HD)4	4.27	-17.5	23.0	-15.7	-6.05	-10.2	-12.9	11.5	-12.4	-10.1
1/T(HD)5								-11.5	12.5	10.1
N(AZP/FST)										
A(AZP)	-540.	-12129.	-23430.	-9456.	-1867.	-4306.	-7765.	-5989.	-5624.	-4209.
1/T(AZP)1	-.0514	-.000207	.000127	-.000356	-.000194	-.00287	-.000776	-.00104	-.000385	-.00117
1/T(AZP)2	.0543	.0148	.0679	.0172	-.0243	.00618	.0131	.00590	.0154	.00419
1/T(AZP)3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1/T(AZP)4								4.22	11.1	4.42
Z(AZP)1	.121	.104	.0917	.0876	.0620	.0625	.0585	.0400	.0294	.0280
W(AZP)1	2.80	10.5	13.9	9.30	3.61	6.09	7.81	7.07	8.56	6.19

TABLE IV-11

F-40 THRUST TRANSFER FUNCTION FACTORS

SAS On — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR										
1/T(DET)1	1.05	-.0270	.902	-.0443	1.14	-.0335	1.04	.990	1.02	.991
1/T(DET)2	20.6	.0413	17.9	.0590	21.4	.0344	22.2	1.68	3.34	1.50
1/T(DET)3		.924		.988		1.07		21.1	18.5	20.7
Z(DET)1	.143	(21.2)	.755	(22.1)	-.0469	(22.2)	.204	.159	.421	.158
W(DET)1	.0880		.0454		.0540		.0389	.0291	.0192	.0218
Z(DET)2	.313	.627	.657	.504	.294	.342	.357	.337	.289	.263
W(DET)2	1.12	5.53	10.1	4.87	1.56	3.03	5.22	4.98	6.46	4.56
Z(DET)3	.431	.0181	-.00157	.0256	.170	.0781	.0315	.106	.173	.135
W(DET)3	6.06	29.4	39.2	24.9	11.5	16.7	22.4	22.6	34.5	22.6
NUMERATORS										
N(U /DTH)										
A(U)	.000965	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823
1/T(U)1	.00561	.00340	.00128	.00241	-.00271	.000946	-.000438	-.000999	-.000410	-.00110
1/T(U)2	1.05	.924	.902	.988	1.15	1.07	1.04	.990	1.02	.991
1/T(U)3	20.6	21.2	17.9	22.1	21.4	22.2	22.2	1.69	3.35	1.51
1/T(U)4								21.1	18.5	20.7
Z(U)1	.359	.627	.655	.505	.375	.339	.367	.360	.305	.303
W(U)1	1.15	5.54	10.1	4.89	1.60	3.06	5.22	4.97	6.46	4.55
Z(U)2	.436	.0181	-.00200	.0256	.172	.0786	.0319	.107	.173	.135
W(U)2	6.07	29.4	39.2	24.9	11.5	15.7	22.4	22.6	34.5	22.6
N(W /DTH)										
A(W)	-.878E-4	-.754E-4	-.754E-4	-.755E-4	-.754E-4	-.755E-4	-.755E-4	-.756E-4	-.756E-4	-.756E-4
1/T(W)1	.0248	.00116	-.00173	.000299	.998	-.000597	-.00306	-.00293	-.00215	-.00306
1/T(W)2	.381	.493	-.625	.892	20.2	.719	-.578	-.532	-.221	-.276
1/T(W)3	1.03	.962	.927	1.32	24.4	1.00	.974	1.01	.988	1.01
1/T(W)4	13.1	26.2	27.2	24.3	(.974)	22.2	23.2	1.17	2.90	1.19
1/T(W)5	20.9	33.6	48.0	37.4	(.0509)	35.0	47.0	22.2	21.1	21.5
1/T(W)6								58.6	83.6	70.0
Z(W)1	.592	.0483	.0261	.0630	.217	.124	.0751	.151	.188	.167
W(W)1	5.25	29.0	38.8	24.3	10.9	16.0	21.5	22.2	34.7	22.4

TABLE IV-11 (Concluded)

N(THE/DTH)										
A(THE)	-.467E-5	-.298E-5	-.298E-5	-.299E-5	-.298E-5	-.300E-5	-.300E-5	-.302E-5	-.303E-5	-.303E-5
1/T(THE)1	-.0923	.250	1.00	.391	-.185	.127	.420	.273	.266	.199
1/T(THE)2	.901	1.00	-1.10	1.06	.444	.065	-.949	-.887	-.516	-.516
1/T(THE)3	1.00	1.11	1.13	1.43	1.00	1.00	1.00	1.00	1.00	1.00
1/T(THE)4	20.3	23.2	23.8	23.1	21.2	22.2	22.8	1.29	2.95	1.24
1/T(THE)5								21.9	20.6	21.3
Z(THE)1	.478	.0457	.0246	.0556	.197	.110	.0643	.146	.189	.165
W(THE)1	5.04	28.4	38.0	23.8	10.7	15.7	21.1	21.9	34.5	22.2
N(HD /DTH)										
A(HD)	.000282	.797E-4	.711E-4	.826E-4	.000209	.000113	.985E-4	.000113	.957E-4	.000123
1/T(HD)1	.993	.339	.935	.791	.655	-1.13	.884	.520	.694	.361
1/T(HD)2	1.22	.571	(-.941)	1.25	1.46	2.60	3.36	.978	1.31	.983
1/T(HD)3	20.6	-3.45	(2.40)	-2.88	21.4	22.2	22.3	3.27	4.51	2.14
1/T(HD)4		8.39		6.37				21.2	18.7	20.8
Z(HD)1	-.0437	(21.4)	.983	(22.2)	.0387	.977	-.116	.0934	.140	.180
W(HD)1	.463		16.4		.798	.888	2.11	2.66	2.68	2.68
Z(HD)2	.438	.0229	.00284	.0305	.172	.0822	.0356	.111	.176	.139
W(HD)2	5.95	29.2	38.9	24.6	11.4	16.5	22.1	22.5	34.5	22.5
N(AZP/DTH)										
A(AZP)	-.120E-4	-.272E-4	-.272E-4	-.270E-4	-.272E-4	-.269E-4	-.268E-4	-.267E-4	-.265E-4	-.266E-4
1/T(AZP)1	-.0214	-.000189	.000137	-.000256	-.00872	-.00168	-.000768	-.00100	-.000377	-.00106
1/T(AZP)2	1.04	.324	.940	.764	.994	.424	.928	.858	.904	.860
1/T(AZP)3	8.98	.968	(-.666)	1.23	4.54	1.00	9.01	.947	2.13	.940
1/T(AZP)4	23.3	-5.34	(2.65)	-4.58	21.7	-3.01	21.1	9.71	(-.142)	7.12
1/T(AZP)5				13.4		6.52		19.5	(2.28)	19.5
Z(AZP)1	-.800	.956	.842	(19.4)	-.881	(22.1)	-.416	-.196	.938	-.150
W(AZP)1	.682	18.0	22.8		.941		2.30	2.48	14.0	2.08
Z(AZP)2	.652	-.00329	-.0197	.00452	.163	.0586	.0158	.0760	.153	.105
W(AZP)2	7.11	30.5	40.8	26.1	12.4	17.7	23.9	23.8	34.7	23.3

TABLE IV-12

F-4C LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.90C	.600	.900	1.20	1.50	2.15	1.80
Bobweight Loop Open										
D(G)/D(U) (DEG/KT)	-.0221	-.0440	-.205	-.05C6	.0737	-.0101	-.0370	-.0147	-.0453	-.00023
N/A (G/RAD)	3.11	40.5	72.6	32.1	5.06	13.8	21.4	18.3	25.1	14.1
DE/G (DEG/G)	6.94	.867	.827	1.25	4.54	2.99	3.64	5.65	6.08	8.44
CAP (RAD/SEC/SEC/G)	.176	.488	.880	.562	.388	.595	1.31	1.58	1.70	1.66
PHUGOID(2) (SEC) (TUCK(2))	--	(18.4)	--	(11.3)	--	(15.2)	--	--	--	--
1/C(1/10)	2.08	1.17	.935	.883	.731	.626	.447	.279	.176	.178
Bobweight Loop Closed										
FST/KT (LB/KT)	-.0191	.0203	-.0734	.C511	-.0279	.0199	-.0613	--	--	--
FST/G (LB/G)	7.13	12.5	17.9	12.6	1C.2	12.2	21.3	--	--	--

TABLE IV-13

F-4C LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
YV	-.0918	-.335	-.486	-.215	-.0566	-.0921	-.151	-.118	-.133	-.0768
YB	-21.1	-299.	-597.	-205.	-33.1	-80.6	-176.	-171.	-277.	-134.
LB'	-10.4	-26.3	-47.0	-27.4	-10.7	-18.3	-14.1	-11.7	-8.67	-8.66
NB'	1.44	15.6	38.2	11.5	1.66	4.97	12.3	9.90	8.37	5.18
LP'	-1.43	-3.04	-3.11	-2.27	-.799	-1.24	-1.38	-1.00	-1.08	-.757
NP'	-.0260	-.0372	.0184	-.0260	-.0179	-.0504	-.0378	-.0170	.0153	-.00913
LR'	.929	.817	.802	.638	.309	.395	.318	.328	.217	.198
NR'	-.215	-.739	-1.20	-.530	-.134	-.238	-.397	-.309	-.273	-.181
Y*DA	-.0130	-.00744	-.0102	-.00459	-.00151	-.00227	-.00302	-.00199	-.00169	-.000329
L'DA	2.74	22.2	19.0	17.9	4.70	0.00	10.9	6.78	5.35	4.67
N'CA	.416	.923	2.45	.747	.0887	.195	.667	.276	.357	.0567
Y*DR	.0174	.0442	.0307	.0281	.0113	.0142	.0132	.00988	.00847	.00614
L'DR	.699	7.32	9.26	5.07	.768	1.95	2.99	1.95	2.57	1.21
N'DR	-.670	-7.80	-8.80	-5.58	-1.36	-2.61	-3.19	-2.03	-1.86	-1.31

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.600	1.10	.9CC	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR										
1/T(DET)1	.0147	.00469	.00568	.00548	.0173	.00969	.00187	-.000179	.000550	.000226
1/T(DET)2	1.15	3.10	3.13	2.33	.650	1.33	1.40	.996	1.04	.748
Z(DET)1	.156	.125	.134	.0932	.0881	.0491	.0727	.0670	.0731	.0535
W(DET)1	1.82	4.01	6.21	3.45	1.83	2.43	3.57	3.23	2.93	2.58
NUMERATORS										
N(B /DA)										
A(B)	-.0130	-.00744	-.0102	-.00455	-.00151	-.00227	-.00302	-.00199	-.00169	-.000329
1/T(B)1	-10.4	-.425	-.0664	-.407	.121	.127	-.487	-.760	-.0669	.155
1/T(B)2	(.297)	1.77	3.08	1.35	.433	2.70	.704	.930	1.69	.479
1/T(B)3	(1.05)	111.	249.	121.	-450.	-115.	121.	35.1	134.	-444.
N(P /DA)										
A(P)	2.74	22.2	15.0	17.5	4.70	0.00	10.9	6.80	5.35	4.67
1/T(P)1	-.0285	-.000186	.000135	-.000252	-.00908	-.00166	-.000766	-.00100	-.000376	-.00106
Z(P)1	.152	.136	.135	.109	.0767	.0742	.0788	.0691	.0706	.0522
W(P)1	1.74	4.11	6.82	3.57	1.36	2.31	3.63	3.25	3.00	2.51
N(R /DA)										
A(R)	.416	.923	2.45	.747	.0887	.195	.067	.376	.357	.0567
1/T(R)1	.746	3.08	4.05	2.35	.331	.733	.964	.494	.711	.320
Z(R)1	.145	-.169	-.200	-.146	-.0560	-.275	-.0224	.0457	.203	-.0741
W(R)1	1.91	2.16	1.34	2.05	4.03	3.69	2.48	2.92	1.71	5.46
N(PHI/DA)										
A(PHI)	2.82	22.2	15.0	17.5	4.71	10.0	10.9	6.80	5.55	4.67
Z(PHI)1	.150	.136	.135	.109	.0722	.0735	.0788	.0691	.0709	.0518
W(PHI)1	1.74	4.11	6.83	3.57	1.38	2.31	3.63	3.25	3.00	2.51
N(AYP/DA)										
A(AYP)	12.0	70.7	69.3	56.6	13.8	29.3	38.0	22.3	17.3	13.5
1/T(AYP)1	-.234	-.311	-.0885	-.243	.125	.119	-.199	.184	-.0738	.104
1/T(AYP)2	.373	.496	1.27	.393	-.400	-.390	.230	-.195	.485	-.257
Z(AYP)1	.149	.114	.0935	.0950	.149	.0765	.0710	.0665	.0230	.0766
W(AYP)1	1.77	4.14	6.40	3.57	1.32	2.34	3.58	3.26	3.28	2.42

F-4C RUDDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	45 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR										
1/T(DET)1	.0147	.00469	.00568	.00848	.0173	.00969	.00187	-.000179	.000558	.000226
1/T(DET)2	1.15	3.10	3.13	2.32	.650	1.33	1.40	.996	1.06	.745
Z(DET)1	.156	.125	.134	.0912	.0881	.0491	.0727	.0670	.0731	.0535
W(DET)1	1.82	4.01	6.21	3.45	1.83	2.43	3.57	3.23	2.93	2.58
NUMERATORS										
N(B /DR)										
A(B)	.0174	.0442	.0307	.0281	.0113	.0142	.0132	.00988	.00867	.00614
1/T(B)1	-.0911	-.00161	.00396	-.00256	-.0240	-.00775	.000300	-.00165	.00190	-.00179
1/T(B)2	1.26	3.09	3.13	2.30	.750	1.26	1.40	.996	1.05	.752
1/T(B)3	46.4	178.	286.	201.	130.	191.	248.	215.	222.	225.
N(P /DR)										
A(P)	.699	7.32	9.26	5.07	.768	1.95	2.99	1.95	2.57	1.21
1/T(P)1	-.0287	-.000188	.000140	-.000254	-.00911	-.00167	-.000771	-.00100	-.000376	-.00106
1/T(P)2	2.53	-3.52	-2.16	4.27	3.91	4.26	-1.58	-1.51	(.0758)	1.79
1/T(P)3	-3.34	3.57	2.92	-4.36	-4.40	-4.59	1.73	1.54	(1.45)	-1.79
N(R /DR)										
A(R)	-.670	-7.80	-8.80	-5.58	-1.36	-2.61	-3.19	-2.03	-1.86	-1.31
1/T(R)1	.917	3.10	3.13	2.32	.366	1.11	1.40	.964	-.172	.432
Z(R)1	.257	.297	.671	.113	.201	.169	.258	.277	(.237)	.326
W(R)1	1.15	.369	.238	.496	1.21	.694	.225	.226	(1.09)	.204
N(PHI/DR)										
A(PHI)	.561	7.28	9.30	5.02	.542	1.83	2.90	1.86	2.52	1.13
1/T(PHI)1	2.67	-1.54	-2.15	4.26	4.51	4.35	-1.63	1.55	(.0642)	1.83
1/T(PHI)2	-4.10	3.57	2.92	-4.42	-5.57	-4.79	1.74	-1.58	(1.46)	-1.88
N(AYP/DR)										
A(AYP)	-4.79	-66.5	-79.0	-49.4	-13.3	-24.4	-27.8	-13.1	-4.95	-7.18
1/T(AYP)1	-.102	-.00390	.00330	-.00565	-.0320	-.0152	-.000537	-.00267	.00246	-.00300
1/T(AYP)2	.504	3.00	3.15	1.93	.368	.766	1.37	.960	1.11	.491
Z(AYP)1	.356	.102	.0552	.118	.130	.138	.0544	.0402	.0400	.0408
W(AYP)1	2.71	5.19	6.92	4.54	2.68	3.29	3.75	4.12	8.48	4.18

TABLE IV-16

F-4C AILERON TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR										
1/T(DET)1	.00233	-.000122	.00468	.00114	.00289	.00176	.00129	-.000595	.00114	-.000318
1/T(DET)2	.905	.852	.534	2.72	.453	1.38	.645	.617	.530	.624
1/T(DET)3	2.03	1.58	3.15	8.01	3.62	5.31	1.38	.992	1.11	.803
Z(DET)1	.393	(3.20)	.657	.763	.332	.508	.752	.608	.572	.582
W(DET)1	1.52	(5.95)	6.68	1.05	1.36	1.01	3.38	3.15	3.24	2.48
NUMERATORS										
N(B /DA)										
A(B)	-.0160	-.00965	-.00937	-.00605	-.00181	-.00294	-.00315	-.00216	-.00187	-.000461
1/T(B)1	.0939	.0124	.0828	.0150	.0136	.0128	.0299	.0354	.0543	.0223
1/T(B)2	.887	-1.04	-.154	-1.14	.398	1.62	-1.68	1.10	-.309	.591
1/T(B)3	-6.92	7.03	4.91	5.78	4.15	10.3	2.24	-4.27	2.13	2.79
1/T(B)4	8.52	128.	246.	137.	-354.	-48.9	129.	55.1	143.	-393.
N(P /DA)										
A(P)	2.64	21.8	15.2	17.3	4.68	9.90	10.9	6.75	5.29	4.64
1/T(P)1	-.0285	-.000187	.000136	-.000294	-.00908	-.00166	-.000757	-.00100	-.000177	-.00106
1/T(P)2	1.09	.592	.513	.710	2.61	5.33	.602	.594	.578	.636
Z(P)1	.867	(2.16)	.675	(1.45)	.543	.764	.766	.626	.590	.598
W(P)1	1.29	(10.2)	7.33	(8.16)	.549	.772	3.48	3.19	3.35	2.42
N(R /DA)										
A(R)	.547	1.31	2.21	.558	.125	.320	.699	.411	.395	.0850
1/T(R)1	.411	.481	.495	.468	.302	.417	.456	.400	.423	.300
1/T(R)2	.904	7.04	5.26	5.87	.719	3.08	1.84	.755	1.36	.623
Z(R)1	.226	-.0496	-.220	-.0272	.467	.417	.271	.305	.399	.414
W(R)1	1.69	1.52	1.38	1.38	3.21	1.68	1.93	2.69	1.53	4.47

TABLE IV-16 (Concluded)

N(PHI/DA)										
A(PHI)	2.76	21.9	15.2	17.4	4.7[illegible]	9.92	10.9	6.77	5.30	4.65
1/T(PHI)1	1.07	.592	.513	.710	3.5[illegible]	5.33	.602	.594	.578	.635
Z(PHI)1	.841	(2.16)	.675	(1.45)	.53[illegible]	.763	.766	.625	.590	.596
W(PHI)1	1.30	(10.2)	7.34	(8.15)	.55[illegible]	.772	3.48	3.18	3.34	2.42
N(AYP/DA)										
A(AYP)	13.2	74.1	67.1	58.5	14.1	30.4	38.3	22.5	17.4	13.6
1/T(AYP)1	.149	.0293	.111	.0254	.0208	.0212	.0486	.0580	.0790	.0371
1/T(AYP)2	-.370	-.579	-.174	-.515	.504	-.675	-.396	-.372	-.174	-.476
1/T(AYP)3	.925	9.30	2.56	7.52	-.880	5.02	1.17	.759	1.14	.615
Z(AYP)1	.610	.641	.475	.632	(1.31)	.770	.673	.573	.470	.641
W(AYP)1	1.64	2.32	6.00	1.94	(3.1[illegible])	1.18	3.33	3.28	3.47	2.63

TABLE IV-17

F-4C RUDDER TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR										
1/T(DET)1	.00233	-.000122	.00468	.00114	.00289	.00176	.00127	-.000595	.00114	-.000318
1/T(DET)2	.905	.852	.534	2.72	.453	1.38	.645	.617	.539	.624
1/T(DET)3	2.03	1.58	3.15	8.01	3.62	5.31	1.38	.992	1.11	.803
Z(DET)1	.393	(3.20)	.657	.763	.332	.508	.752	.608	.572	.562
W(DET)1	1.52	(9.95)	6.68	1.05	1.36	1.01	3.38	3.15	3.24	2.48
NUMERATORS										
N(B /DR)										
A(B)	.0166	.0298	.0229	.0204	.0102	.0117	.0113	.00926	.00854	.00594
1/T(B)1	-.0911	-.00161	.00356	-.00256	-.0240	-.00775	.000301	-.00165	.00190	-.00179
1/T(B)2	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500
1/T(B)3	1.26	3.09	3.13	2.30	.750	1.26	1.40	.996	1.05	.752
1/T(B)4	46.4	178.	286.	201.	130.	191.	248.	215.	222.	225.
N(P /DR)										
A(P)	.669	4.93	6.91	3.69	.690	1.62	2.37	1.83	2.53	1.17
1/T(P)1	-.0287	-.000188	.000140	-.000254	-.00911	-.00167	-.000771	-.00100	-.000376	-.00104
1/T(P)2	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500
1/T(P)3	2.53	-3.52	-2.16	4.27	3.91	4.26	-1.58	-1.51	(.0758)	1.79
1/T(P)4	-3.34	3.57	2.92	-4.38	-4.40	-4.59	1.73	1.54	(1.45)	-1.79

TABLE IX-17 (Concluded)

N(R /DR)										
A(R)	-.641	-5.26	-6.57	-4.06	-1.22	-2.17	-2.73	-1.91	-1.84	-1.27
1/T(R)1	.500	.500	.500	.500	.366	.500	.500	.500	-.172	.500
1/T(R)2	.917	3.10	3.13	2.33	.500	1.11	1.40	.964	.237	.632
Z(R)1	.257	.297	.671	.112	.201	.169	.258	.277	(.500)	.326
W(R)1	1.15	.369	.238	.496	1.21	.694	.225	.276	(1.09)	.294
N(PHI/DR)										
A(PHI)	.536	4.91	6.95	3.65	.487	1.52	4.49	1.74	2.49	1.10
1/T(PHI)1	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500
1/T(PHI)2	2.67	-3.54	-2.15	4.28	4.51	4.35	-1.63	1.55	(.0692)	1.83
1/T(PHI)3	-4.10	3.57	2.92	-4.42	-5.57	-4.79	1.74	-1.58	(1.46)	-1.88
N(AYP/DR)										
A(AYP)	-4.58	-44.8	-59.0	-36.0	-12.0	-20.3	-23.8	-12.3	-4.88	-6.95
1/T(AYP)1	-.102	-.00390	.00330	-.00565	-.0320	-.0152	-.000537	-.00267	.00248	-.00300
1/T(AYP)2	.500	.500	.500	.500	.368	.300	.500	.500	.500	.500
1/T(AYP)3	.604	3.00	3.15	1.93	.500	.766	1.37	.960	1.11	.691
Z(AYP)1	.356	.102	.0552	.118	.130	.138	.0544	.0402	.0400	.0408
W(AYP)1	2.71	5.19	6.92	4.54	2.68	3.29	3.75	4.12	8.48	4.18

TABLE IX-18

F-4C LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80
DR PERIOD (SEC)	3.49	1.58	1.02	1.83	3.45	2.59	1.76	1.95	2.15	2.44
1/C(1/2)	1.43	1.15	1.22	.885	.802	.446	.661	.609	.665	.485
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	3868.	--	--
P(1)	1.90	7.39	5.51	7.75	2.52	6.80	7.93	6.83	5.22	5.79
P(2)	--	7.33	5.42	7.65	2.12	6.28	7.90	6.83	5.21	5.75
P(3)	--	7.52	5.81	7.98	4.00	6.63	7.98	6.85	5.28	5.85
P(2)/P(1)	--	.992	.984	.938	.846	.924	.996	.000	.997	.993
P(OSC)/P(AV)	--	.00847	.0217	.0125	.211	.0335	.00355	.000659	.00415	.00588
W(PHI)/W(D)	.955	1.03	1.10	1.33	.753	.951	1.02	1.01	1.02	.972
DEL-B-MAX	.0738	.0664	.106	.0757	.338	.145	.0521	.0157	.0559	.0562
PHI TO BETA, PHASE	29.1	32.4	16.7	26.4	16.4	-335.	18.2	15.5	16.9	-346.
PHI TO BETA	2.63	1.39	1.16	2.30	2.98	2.79	1.03	1.05	.948	1.21
PHI TO VE	.657	.0891	.0539	.152	.526	.327	.0910	.0940	.0591	.115

F-4C DATA SOURCES

Bonine, W. J., et al, Model F/RF-4B-C Aerodynamic Derivatives, MAC Report 9842, 10 Feb. 1964

Crawford, W. N., and G. Nadler, Static and Dynamic Control System Characteristics for the F-4 Aircraft, MAC Rept. F218, 16 Dec. 1966

Bridges, B. C., Calculated Longitudinal Stability and Performance Characteristics of the F-4B/C/D/J and RF-4B/C Aircraft plus the AN/ASA-32H Automatic Flight Control System, MAC Rept F934, 19 Apr. 1963

Bridges, B. C., Calculated Lateral-Directional Stability and Performance Characteristics of the F-4B/C/D/J and RF-4B/C Aircraft plus the AN/ASA-32H Automatic Flight Control System, MAC Rept. F935, 3 May 1968

NATOPS Flight Manual, Navy Model F-4B Aircraft, NAVAIR 01-245 FDB-1, 1 Nov. 1966

SECTION V

X-15

X-15 BACKGROUND

The X-15 is a single-place, rocket-powered airplane designed for flight at hypersonic speeds and extreme altitudes. The airplane is carried aloft under the right wing of a B-52 and is launched at an altitude of about 45,000 ft and a Mach number of about 0.80. After launch, the X-15 performs a powered flight mission, followed by a deceleration glide prior to vectoring for a landing. With this operational technique, the airplane is capable of attaining a Mach number of 6 and can be flown to and recovered from an altitude in excess of 300,000 feet.

Flights to high altitudes have been made with all three of the X-15 airplanes in two configurations: the basic and the ventral off. The basic configuration is considered here.

Aerodynamic control is provided through conventional aerodynamic surfaces, with vertical surfaces used for yaw control and the horizontal tail for both pitch and roll control. All of the aerodynamic control surfaces are actuated by irreversible hydraulic systems. Control force is provided by bungee for pilot feel. A conventional center stick is used for pitch and roll control, and rudder pedals are used for yaw control; however, a side-located stick is provided for control of pitch and roll in high-acceleration environments at the option of the pilot. Most of the X-15 missions have been made with the side stick, although the pilots used the center stick on their first flights. Only the center stick control is shown here.

The augmentation system shown in this report consists of angular rate feedback loops about all three axes. In addition to the normal $p \rightarrow \delta_a$ roll SAS loop, there is an $r \rightarrow \delta_a$ feedback known as the YAR loop. The gains for each SAS loop are manually set by the pilot. The SAS-on transfer functions given for this airplane assume maximum gain settings for each loop. This may not have been realistic for actual flights.

The flight conditions considered for this airplane are all for straight and level trimmed flight. This is definitely unrealistic for this airplane; however, the intent here is to show general speed and altitude variation effects.

X-15

Nominal Configuration

Zero Fuel

Lower Ventral On

Speed Brakes Retracted

W = 15560 lb

c.g. at .22 $\bar{c}$

I_x = 3650 slug-ft^2

I_y = 80000 slug-ft^2

I_z = 82000 slug-ft^2

I_{xz} = [illegible]90 slug-ft^2

Flight Envelope

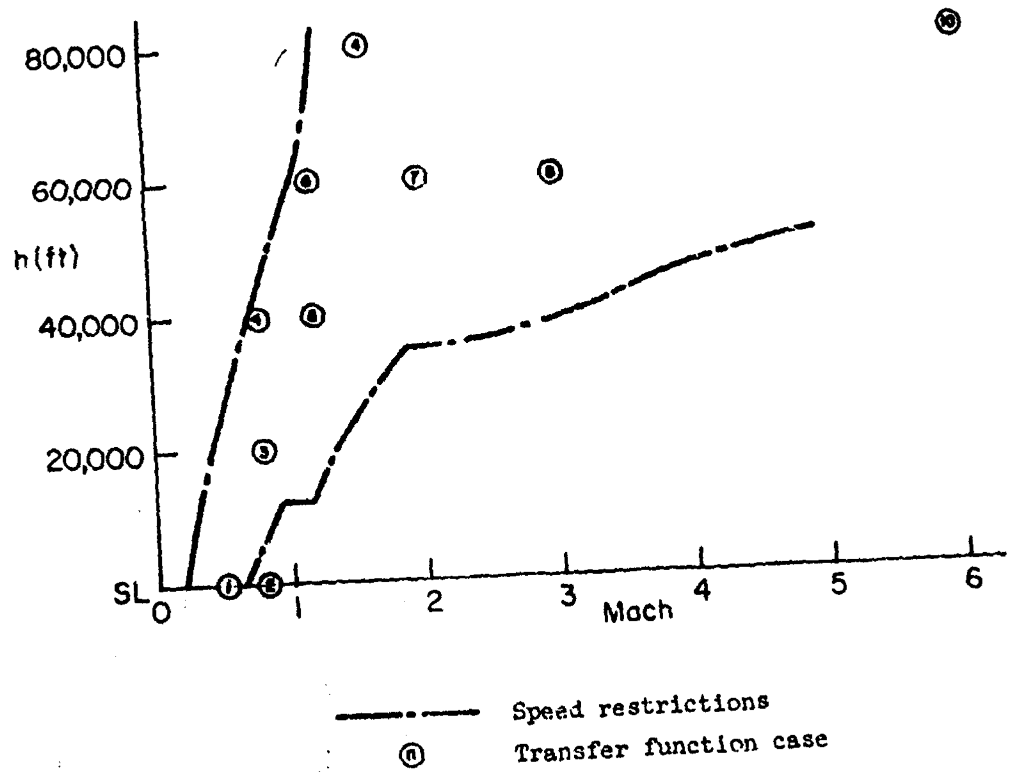


Figure V-1. X-15 Flight Conditions

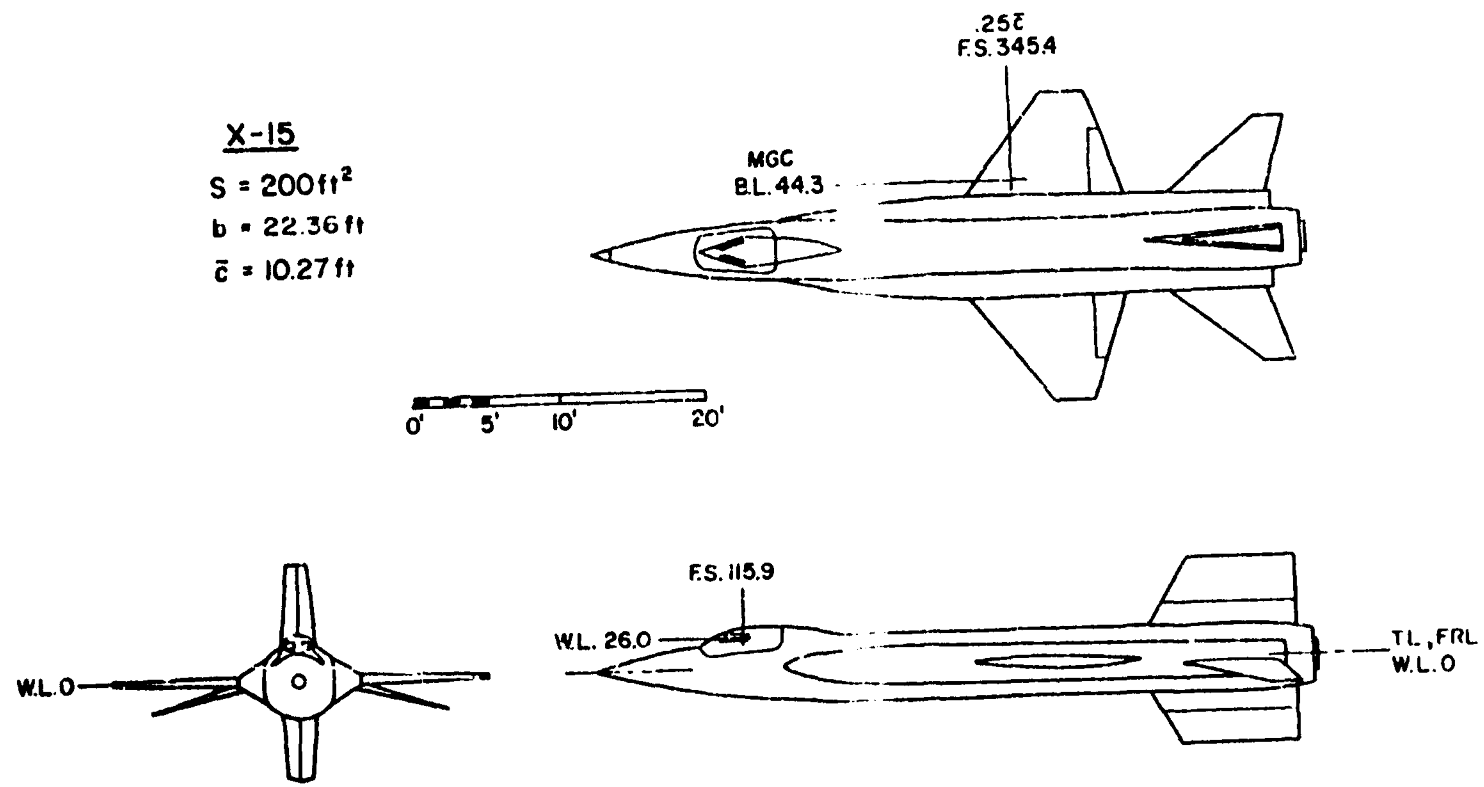


Figure V-2. X-15 General Arrangement

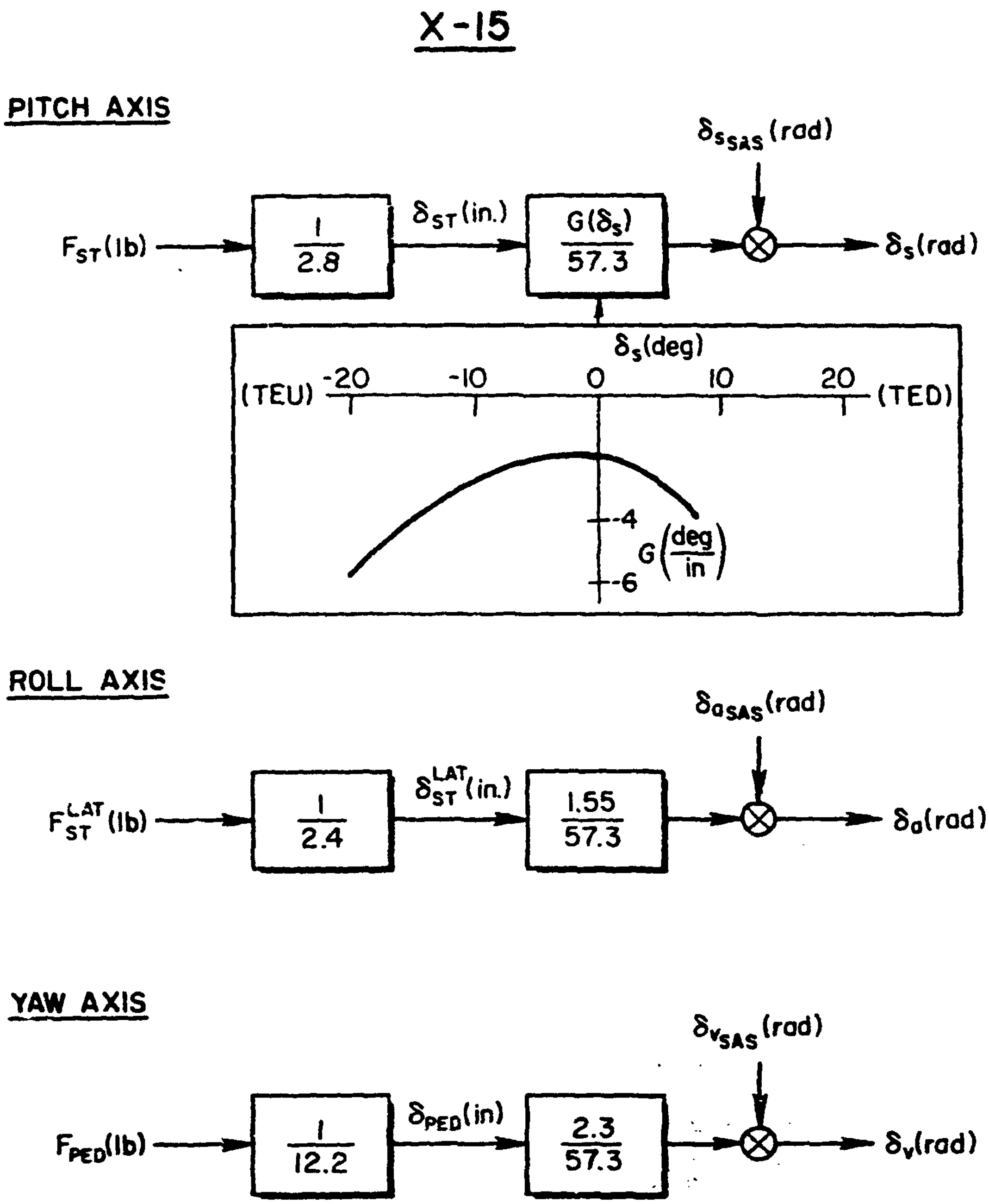
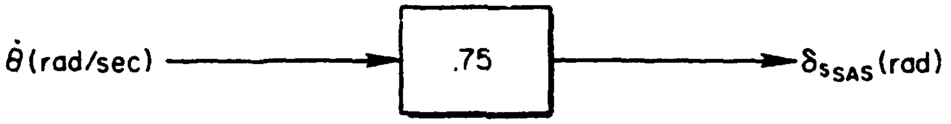


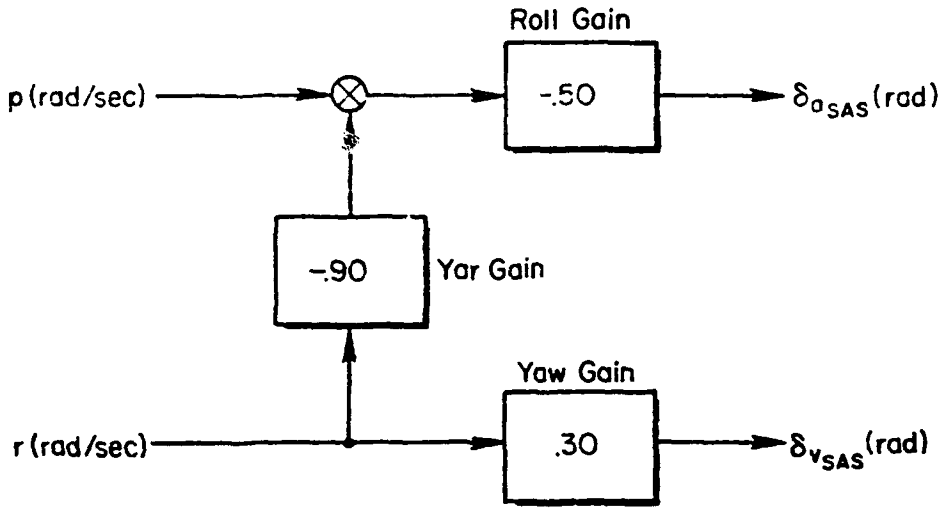
Figure V-3. X-15 Control System

X-15

PITCH SAS



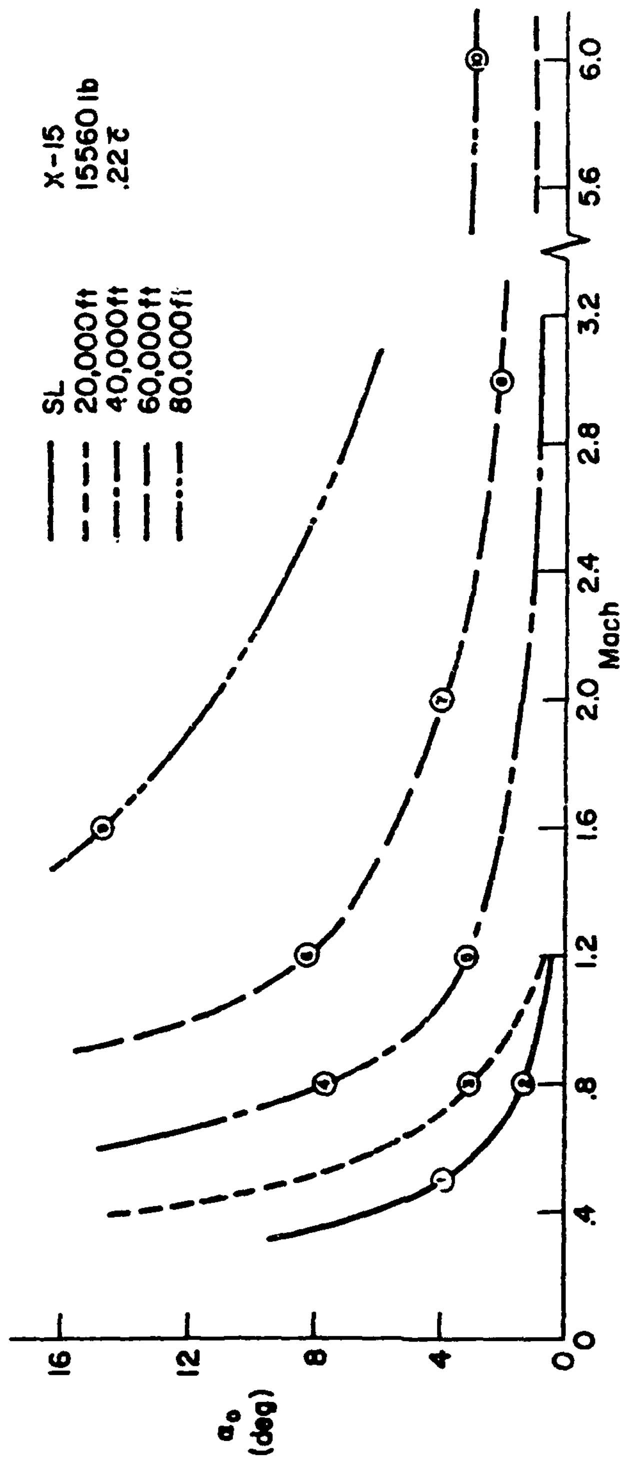
ROLL-YAW-YAR SAS

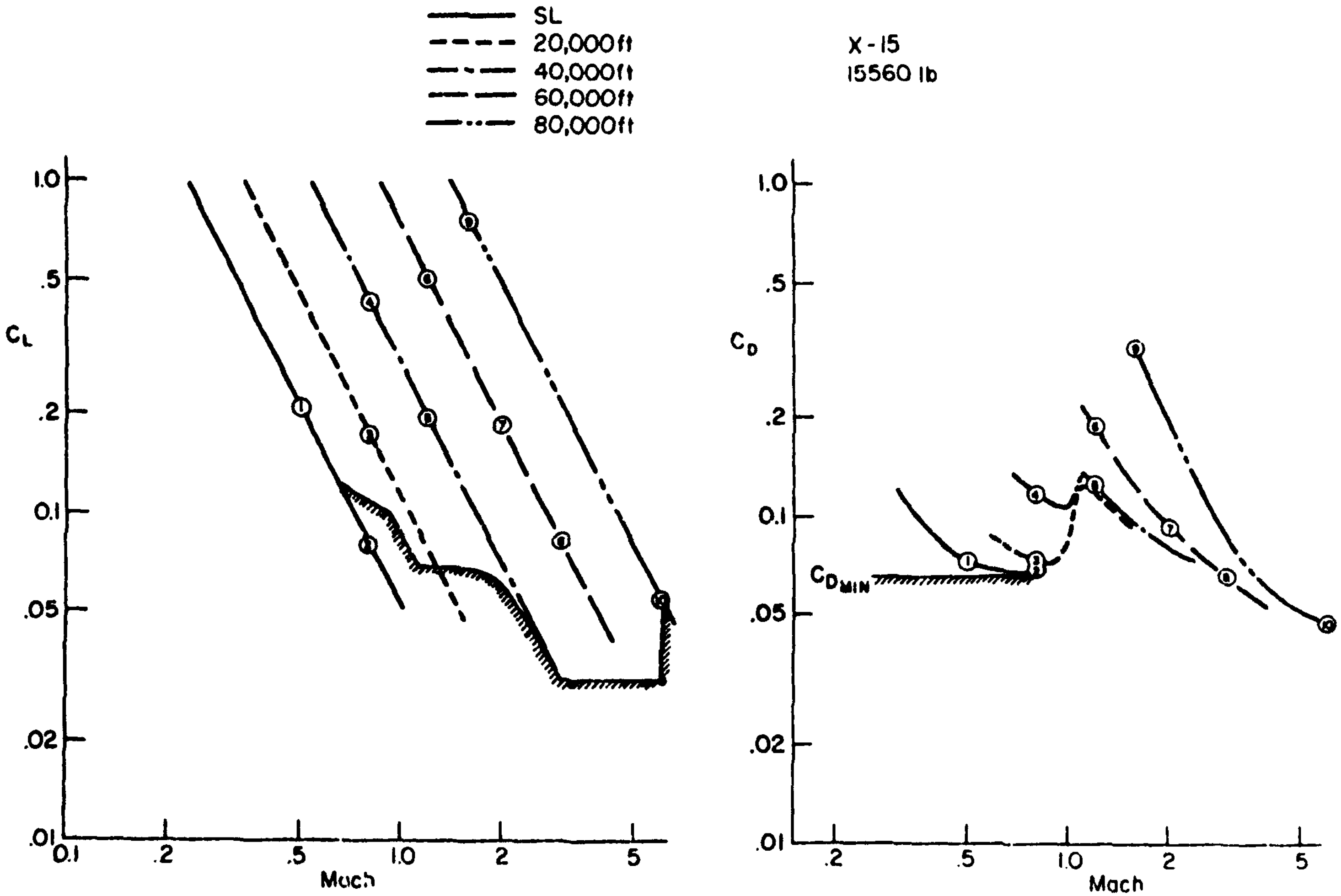


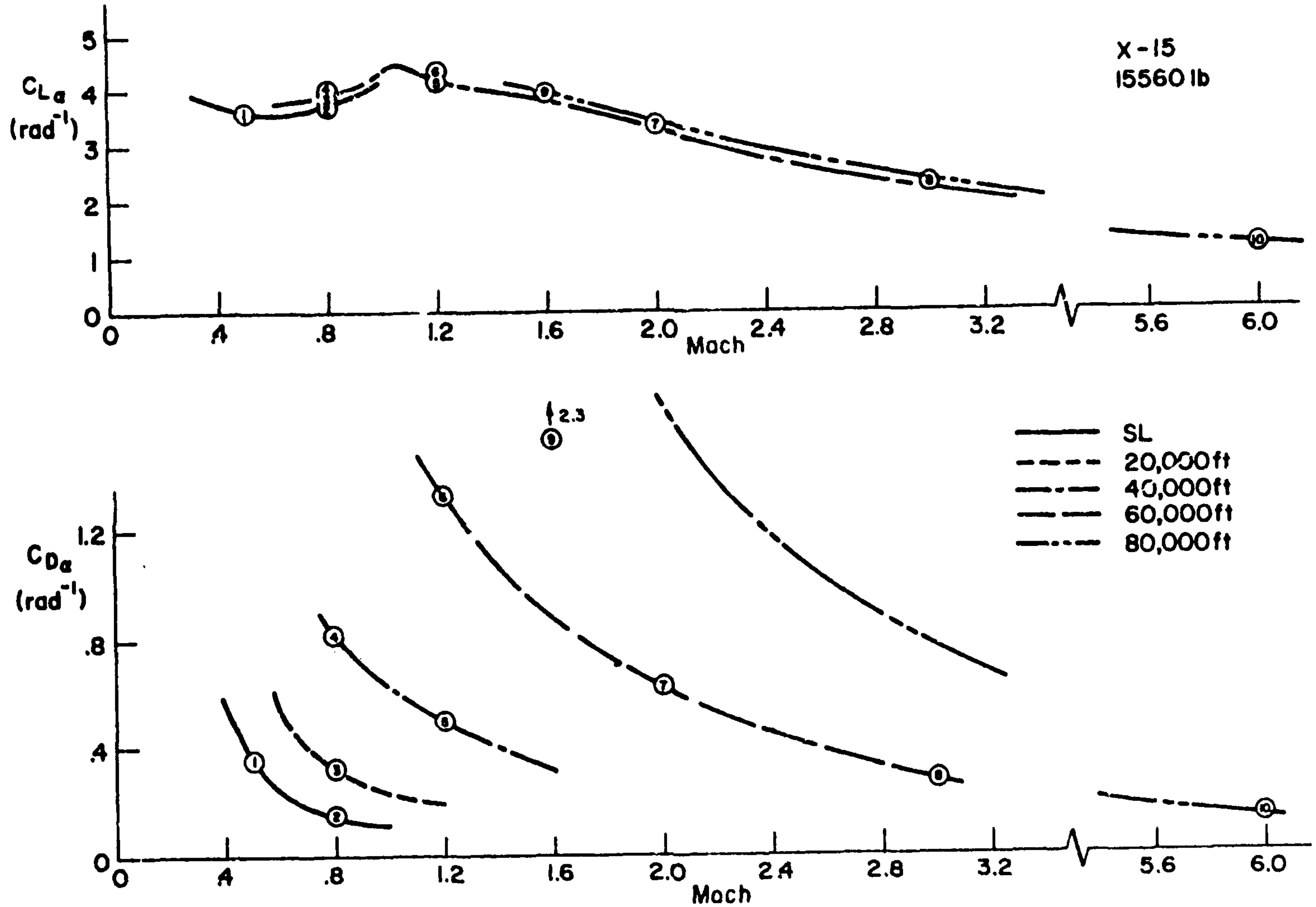
Note:

Gains variable in 10% increments of the maximum values which are shown above. (e.g. roll gains selectable are .05,.10,.15, .20,.25,.30,.35,.40,.45,and .50)

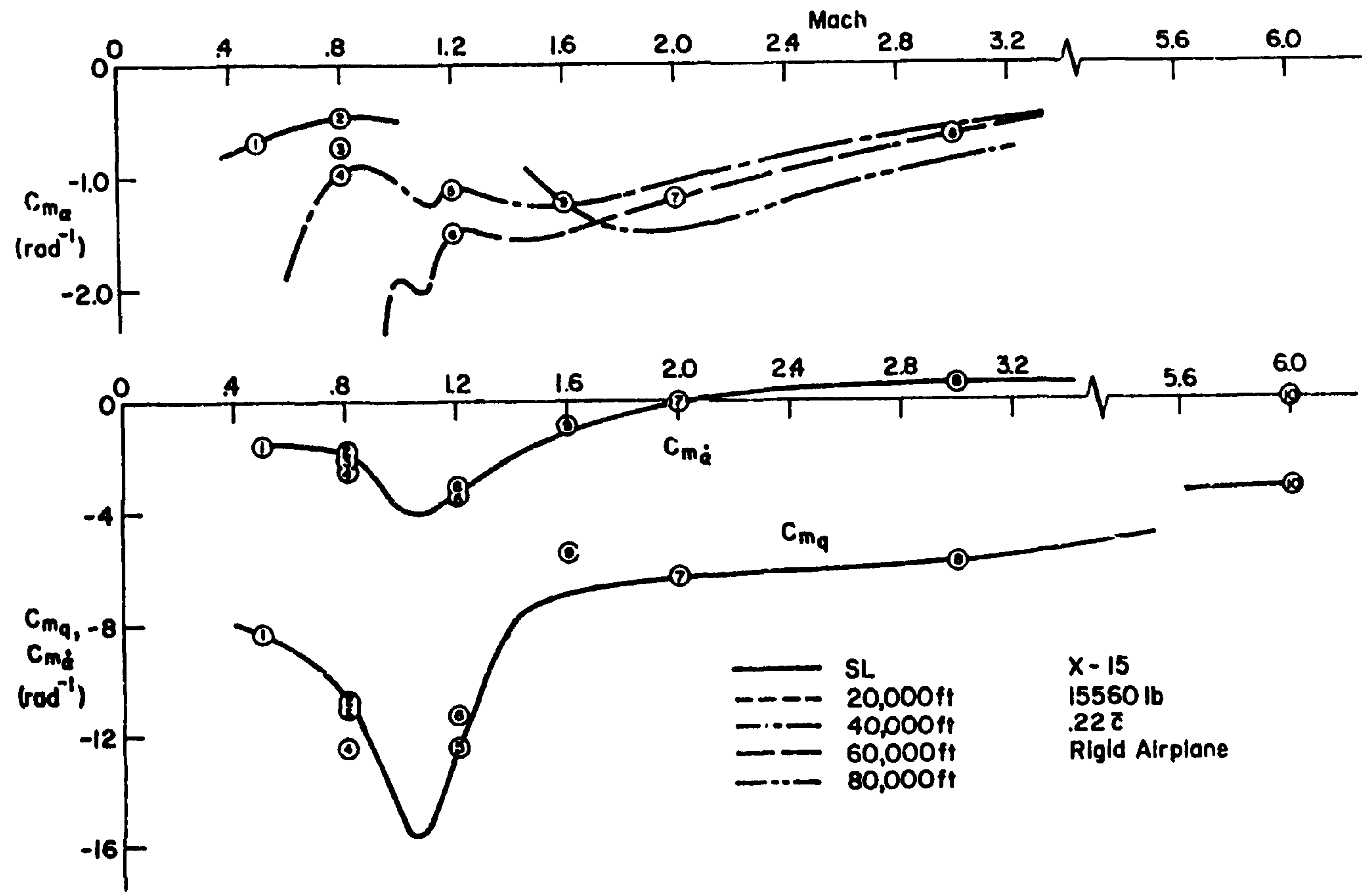
Figure V-4. X-15 Stability Augmentation

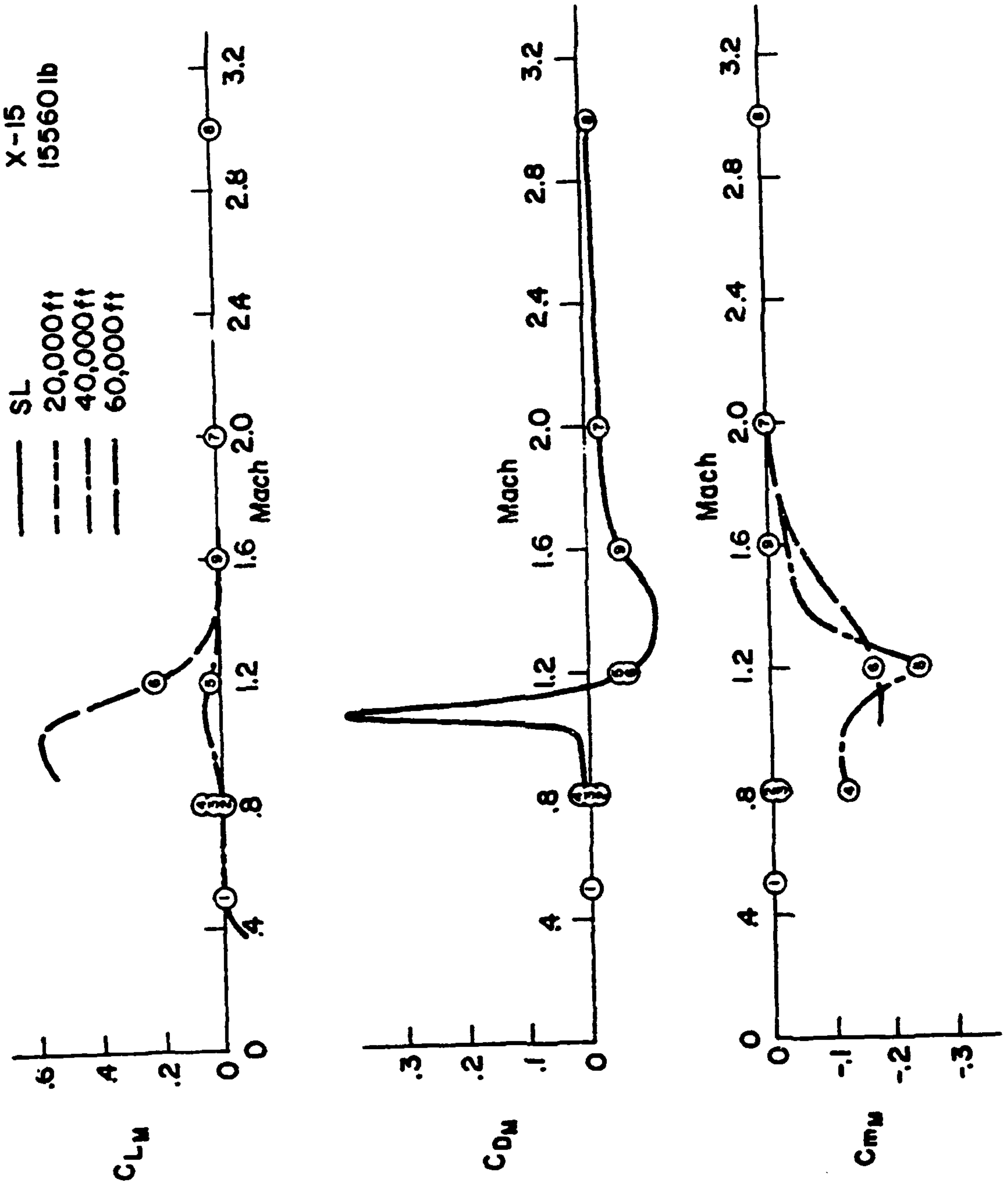

SL
20,000ft
40,000ft
60,000ft
80,000ft
X-15
15560 lb
.22c̄
Mach
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
5.6
6.0
a_o (deg)
0
4
8
12
16

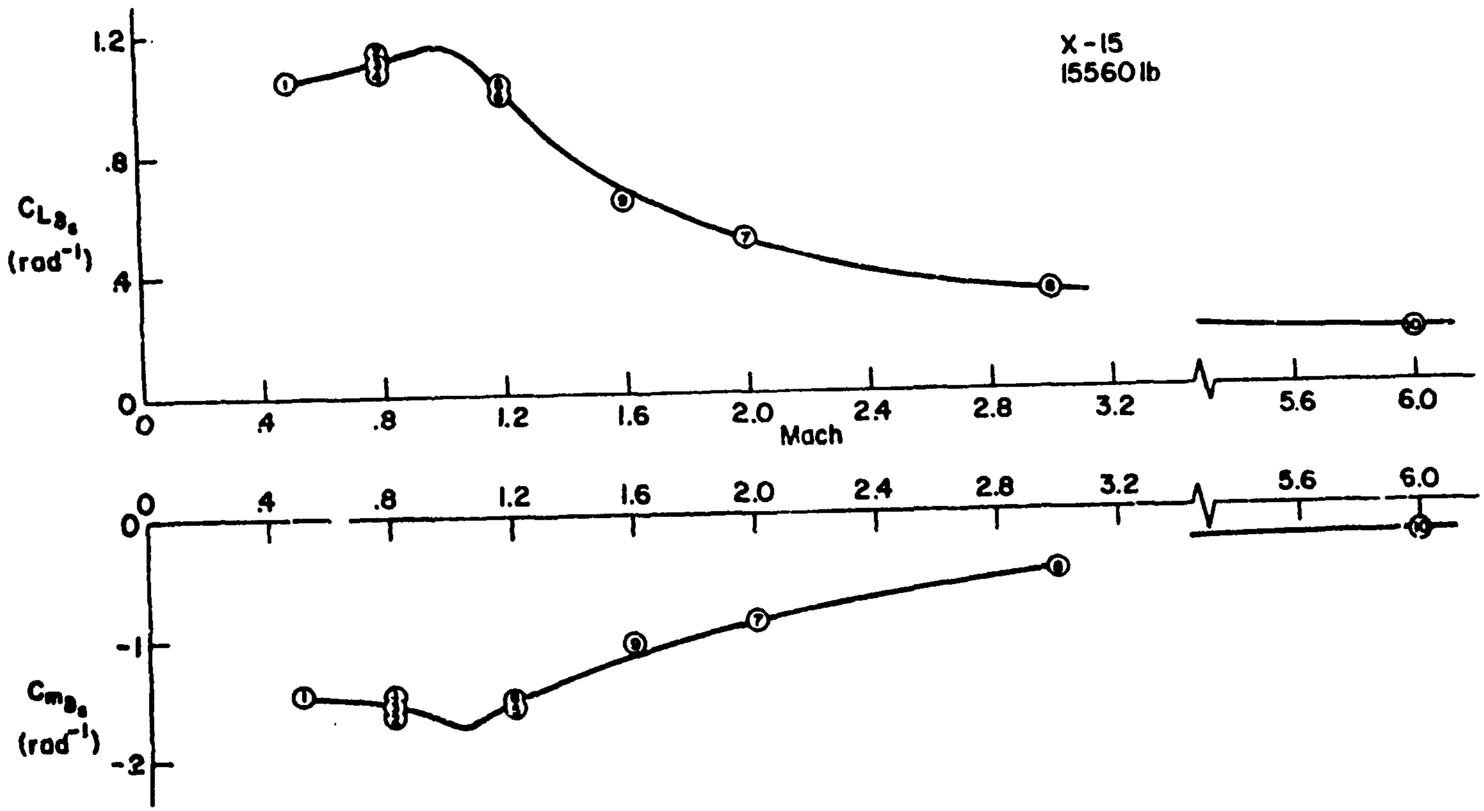

SL
20,000ft
40,000ft
60,000ft
80,000ft
X-15
15560 lb
C_L
C_D
$C_{D_{MIN}}$
Mach
Mach

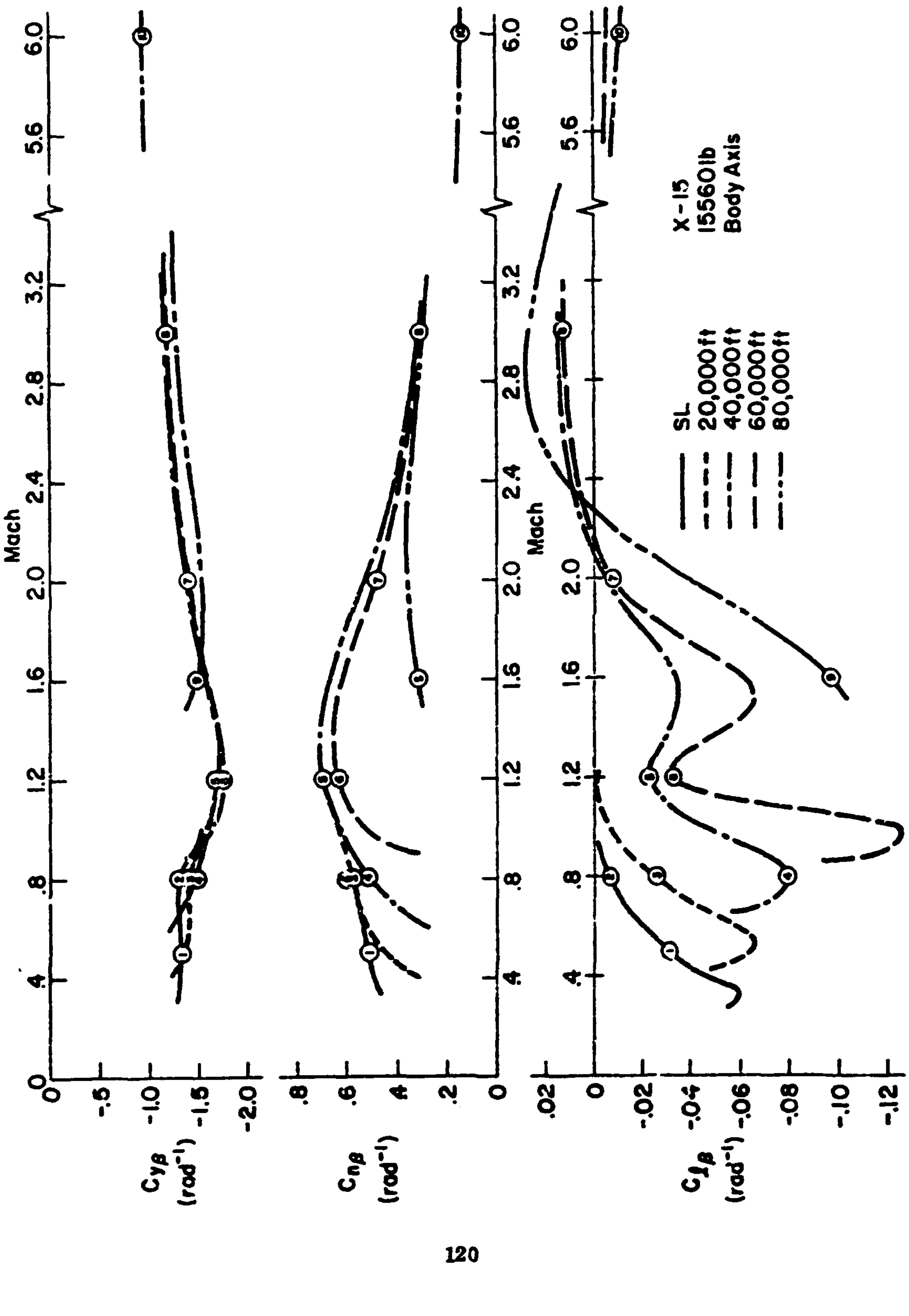


X-15
15560 lb
C_{L_α} (rad^{-1})
C_{D_α} (rad^{-1})
Mach
SL
20,000 ft
40,000 ft
60,000 ft
80,000 ft
2.3

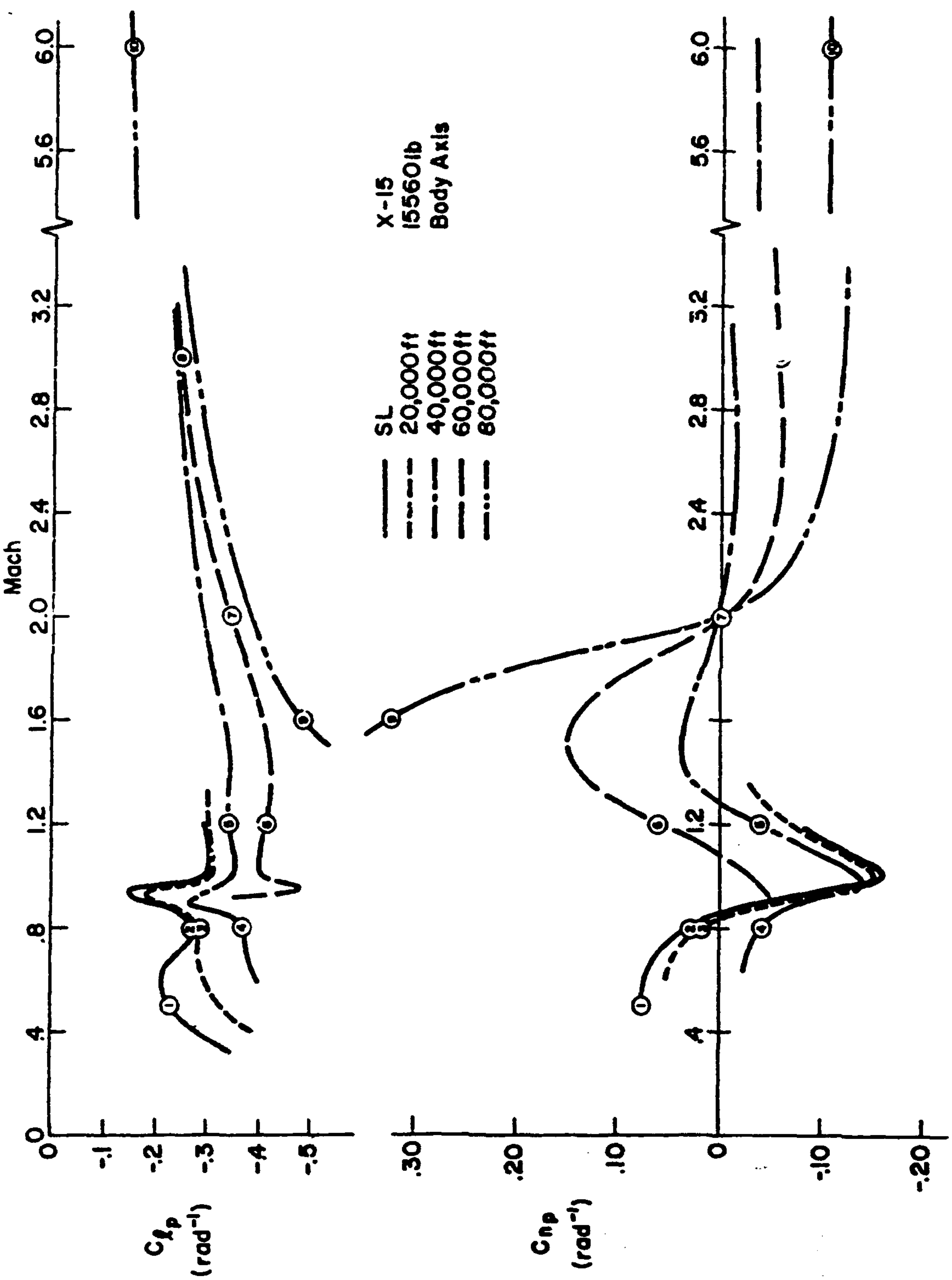

Mach
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
5.6
6.0
C_{m_α}
(rad^{-1})
-1.0
-2.0
$C_{m_{\dot\alpha}}$
C_{m_q}
C_{m_q}, $C_{m_{\dot\alpha}}$
(rad^{-1})
-4
-8
-12
-16
SL
20,000ft
40,000ft
60,000ft
80,000ft
X - 15
15560 lb
.22 $\bar{c}$
Rigid Airplane


X-15
15560 lb
SL
20,000ft
40,000ft
60,000ft
Mach
C_{L_M}
C_{D_M}
C_{m_M}

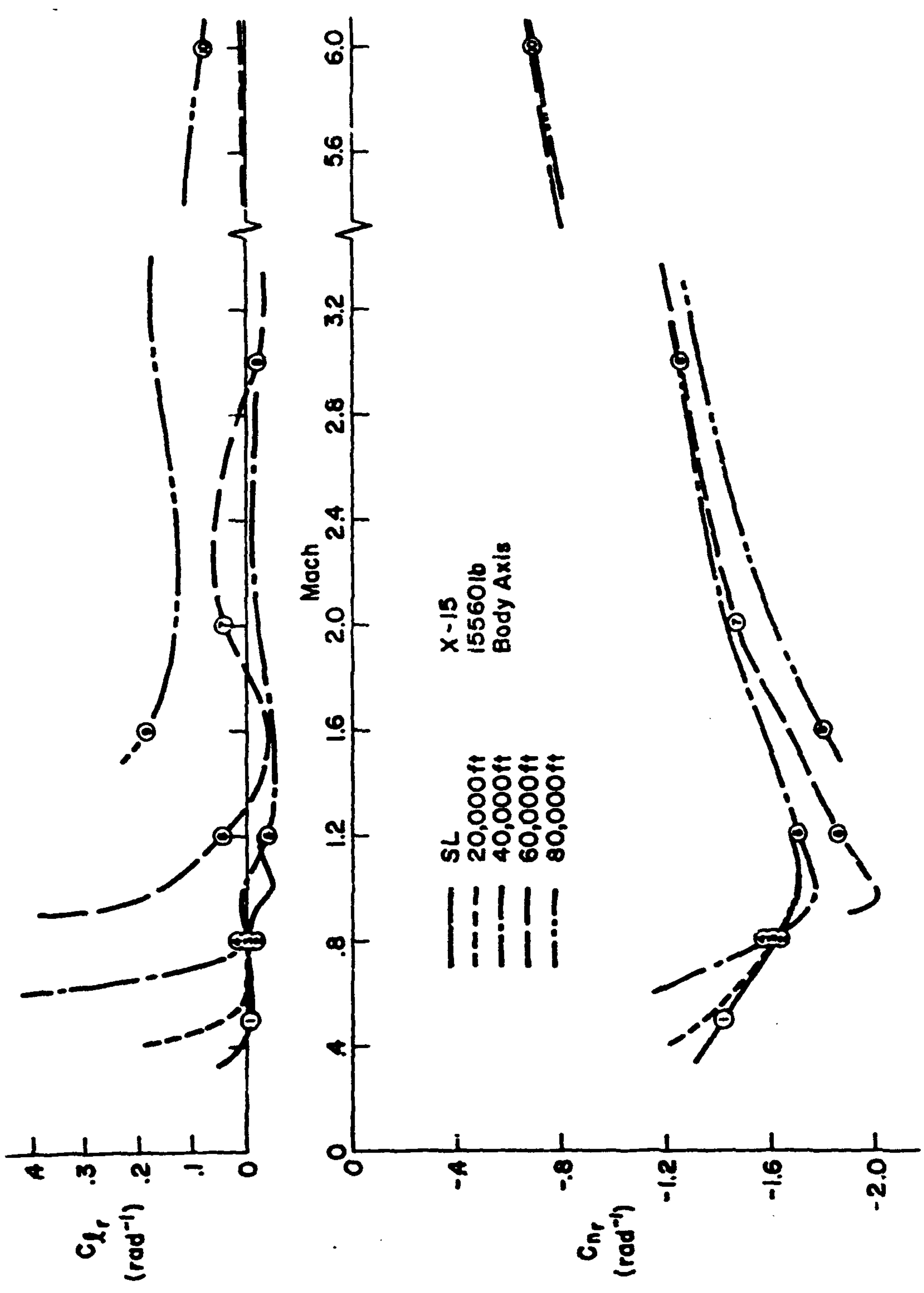

X-15
15560 lb
$C_{L_{\delta_e}}$ (rad^{-1})
$C_{m_{\delta_e}}$ (rad^{-1})
Mach
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
5.6
6.0
-1
-2



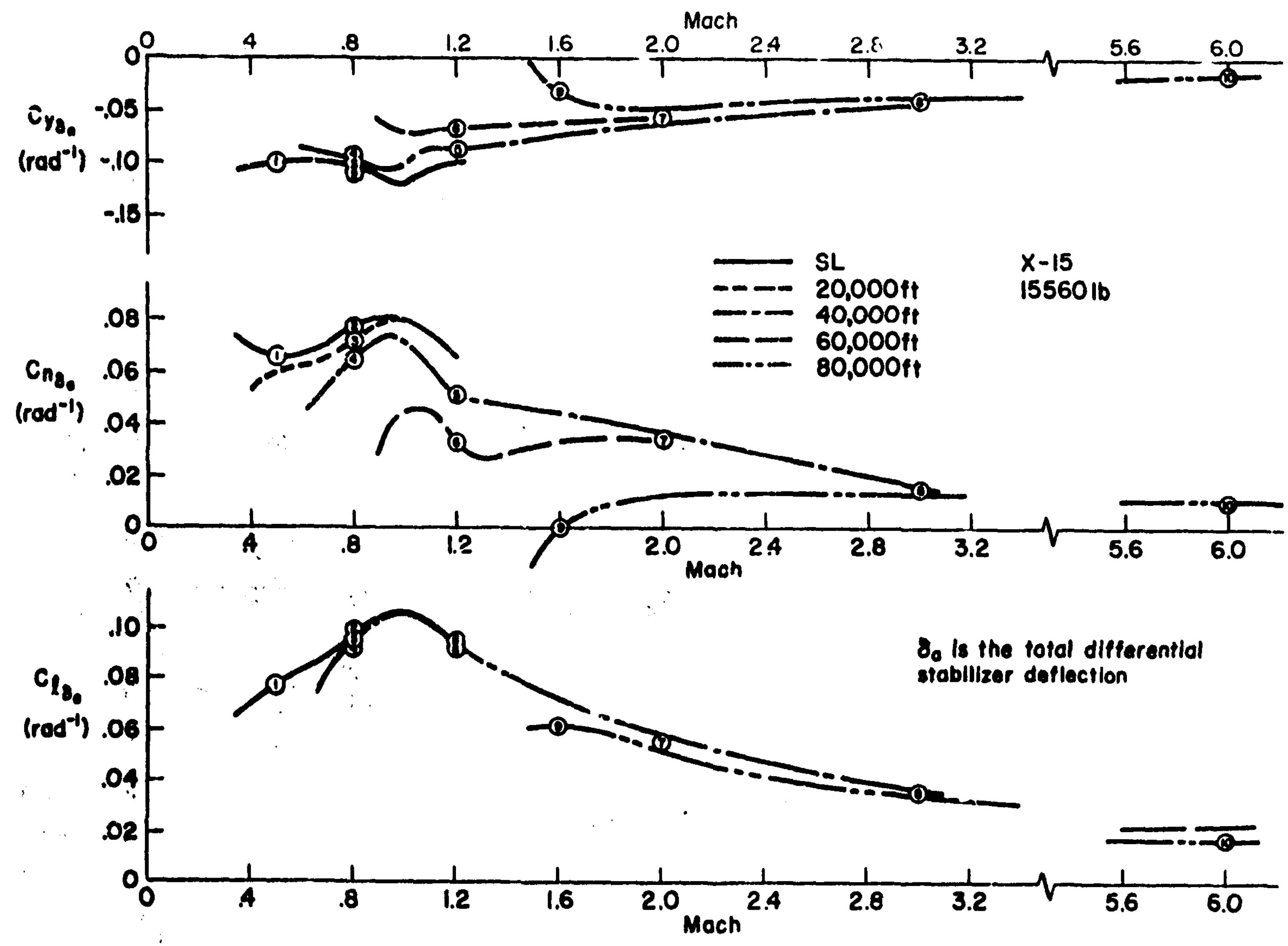
C_{y_β} (rad^{-1})
C_{n_β} (rad^{-1})
C_{l_β} (rad^{-1})
Mach
Mach
X-15
15560 lb
Body Axis
SL
20,000 ft
40,000 ft
60,000 ft
80,000 ft

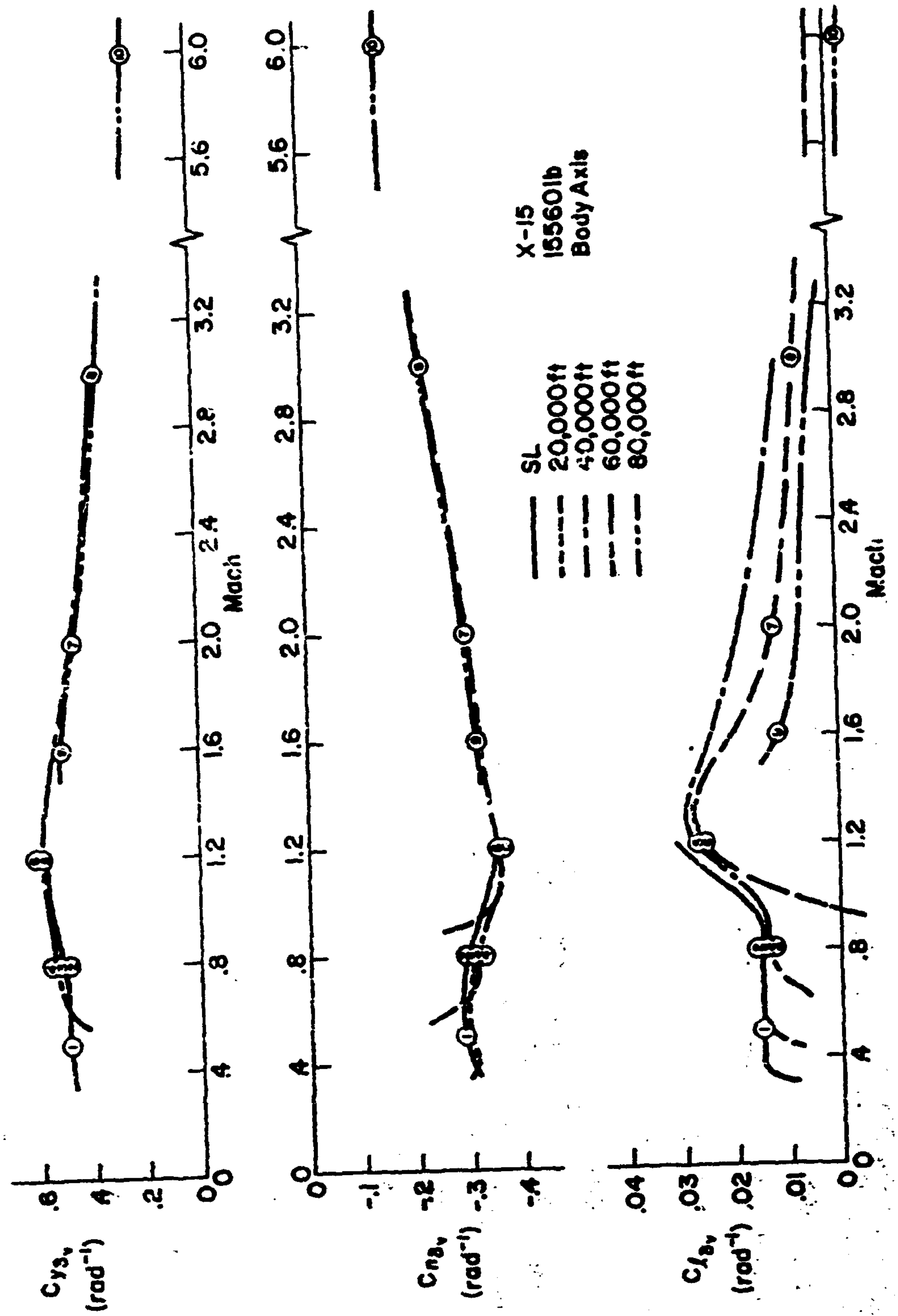


X-15
15560lb
Body Axis
SL
20,000ft
40,000ft
60,000ft
80,000ft
Mach
C_{ℓ_p} (rad^{-1})
C_{n_p} (rad^{-1})
0
-.1
-.2
-.3
-.4
-.5
.30
.20
.10
0
-.10
-.20
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
5.6
6.0



C_{ℓ_r} (rad⁻¹)
C_{n_r} (rad⁻¹)
Mach
SL
20,000ft
40,000ft
60,000ft
80,000ft
X-15
15560lb
Body Axis


Mach
$C_{y_{\delta_a}}$ (rad^{-1})
$C_{n_{\delta_a}}$ (rad^{-1})
$C_{l_{\delta_a}}$ (rad^{-1})
SL
20,000ft
40,000ft
60,000ft
80,000ft
X-15
15560 lb
δ_a is the total differential stabilizer deflection



$C_{y_{\delta_v}}$ (rad^{-1})
$C_{n_{\delta_v}}$ (rad^{-1})
$C_{l_{\delta_v}}$ (rad^{-1})
Mach
X-15
15560 lb
Body Axis
SL
20,000 ft
40,000 ft
60,000 ft
80,000 ft

TABLE V-1

X-15 DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

$S = 200$ sq ft, $b = 22.36$ ft, $\bar{c} = 10.27$ ft

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M(-)	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
VTO(FPS)	558.	893.	830.	774.	1161.	1161.	1936.	2904.	1564.	5845.
VTO(KTAS)	331.	529.	492.	459.	688.	688.	1147.	1720.	927.	3475.
VTO(KCAS)	331.	529.	373.	243.	388.	247.	432.	630.	218.	764.
W(LBS)	15560.	15560.	15560.	15560.	15560.	15560.	15560.	15560.	15560.	15560.
C.G.(MGC)	.220	.220	.220	.220	.220	.220	.220	.220	.220	.220
IX (SLUG-FT SQ)	3650.	3650.	3650.	3650.	3650.	3650.	3650.	3650.	3650.	3650.
IY (SLUG-FT SQ)	80003.	80003.	80003.	80003.	80003.	80003.	80003.	80003.	80003.	80003.
IZ (SLUG-FT SQ)	82003.	82003.	82003.	82003.	82003.	82003.	82003.	82003.	82003.	82003.
IXZ(SLUG-FT SQ)	590.	590.	590.	590.	590.	590.	590.	590.	590.	590.
EPSILON(DEG)	-.431	-.431	-.431	-.431	-.431	-.431	-.431	-.431	-.431	-.431
Q(PSF)	370.	948.	436.	177.	397.	153.	424.	954.	106.	1489.
QC(PSF)	394.	1109.	510.	207.	555.	213.	703.	1675.	166.	2737.
ALPHA(DEG)	4.00	1.30	3.00	7.70	3.20	8.30	4.00	2.20	14.7	3.00
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
LZP(FT)	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20
ITH(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LTH(FT)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE V-2

X-15 LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
XU *	-.0339	-.0601	-.0292	-.0134	-.0216	-.00516	-.00871	-.0101	-.00111	-.00916
ZU *	-.0471	-.0253	-.0335	-.0323	-.0281	-.0348	-.0117	-.0106	-.0113	-.00551
MU *	.000808	.000278	.000279	.000188	-.00199	.495E-4	.000471	.000210	.000529	.430E-4
XW	.0269	.00105	.0111	.0149	-.00810	-.00893	-.0190	-.0148	-.0127	-.00215
ZW	-1.01	-1.66	-.845	-.398	-.602	-.261	-.311	-.323	-.132	-.121
MW	-.0116	-.0123	-.00945	-.00559	-.00979	-.00511	-.00673	-.00548	-.00202	-.000820
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-.000250	-.000282	-.000150	-.923E-4	-.000124	-.472E-4	0.	.894E-5	-.607E-5	0.
MQ	-.735	-1.53	-.755	-.376	-.559	-.194	-.182	-.251	-.0402	-.107
XDS	11.2	9.78	10.4	10.8	9.27	9.21	6.24	4.85	7.11	5.64
ZDS	-160.	-431.	-198.	-79.6	-166.	-63.1	-89.2	-126.	-27.1	-108.
MDS	-13.8	-37.7	-17.4	-7.03	-15.5	-5.96	-9.80	-12.2	-2.85	-8.79

TABLE V-3

X-15 STABILIZER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
DENOMINATOR										
Z(DET)1	.247	.716	.338	.173	(-.0469)	.108	.264	.366	.262	.626
W(DET)1	.0773	.0424	.0452	.0419	(.0552)	.0317	.0232	.0158	.0294	.00788
Z(DET)2	.351	.467	.296	.200	.194	.104	.0675	.0683	.0488	.0519
W(DET)2	2.68	3.67	2.91	2.11	3.40	2.43	3.62	4.00	1.81	2.20
NUMERATORS										
N(U /DS)										
A(U)	11.2	9.78	10.4	10.8	5.27	9.21	6.24	4.85	7.11	5.64
1/T(U)1	47.8	1.22	72.6	67.8	.247	.0926	.0795	.0840	.0386	.0548
1/T(U)2	(.849)	1.98	(.928)	(.926)	.996	.420	.741	.913	.221	.212
1/T(U)3	(.853)	78.1	(.739)	(.321)	109.	109.	212.	282.	159.	479.
N(W /DS)										
A(W)	-160.	-431.	-198.	-79.6	-166.	-63.1	-89.2	-126.	-27.1	-108.
1/T(W)1	48.6	79.7	73.3	68.1	109.	109.	212.	282.	159.	479.
Z(W)1	.299	.967	.394	.166	.876	.100	.261	.431	-.0363	.830
W(W)1	.0555	.0310	.0367	.0367	.0124	.0309	.0160	.0117	.0184	.00552
N(THE/DS)										
A(THE)	-13.7	-37.6	-17.3	-7.02	-15.5	-5.96	-9.80	-12.3	-2.85	-8.79
1/T(THE)1	.0344	.0600	.0293	.0138	.0226	.00218	.00688	.00919	-.00270	.00898
1/T(THE)2	.881	1.52	.738	.334	.498	.210	.251	.267	.116	.111
N(HD /DS)										
A(HD)	161.	431.	198.	80.3	166.	63.8	89.4	126.	28.0	108.
1/T(HD)1	.0270	.0586	.0256	.00435	.0209	-.00561	.00482	.00833	-.0121	.00869
1/T(HD)2	-6.03	-10.0	-6.87	-4.46	-6.98	-4.47	-7.13	-8.52	-3.90	-7.21
1/T(HD)3	6.92	11.8	7.75	4.93	7.69	4.74	7.32	8.75	3.99	7.32
N(AZP/DS)										
A(AZP)	98.0	276.	128.	52.4	125.	48.9	95.0	104.	26.6	57.7
1/T(AZP)1	-.00446	-.000827	-.00217	-.00711	-.00157	.00116	-.00134	-.000451	-.00155	-.000297
1/T(AZP)2	.0312	.0593	.0276	.0110	.0223	-.00789	.00605	.00873	-.0100	.00872
Z(AZP)1	.0540	.0411	.0286	.0141	.0135	.0148	.0224	.0166	.0210	.00597
W(AZP)1	8.28	13.6	9.10	5.83	8.44	5.32	7.04	9.53	4.21	9.94

TABLE V-4

X-15 STABILIZER TRANSFER FUNCTION FACTORS

SAS On

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
DENOMINATOR										
1/T(DET)1	1.53	.00933	1.35	1.29	-.0350	(.0957)	3.26	2.58	(.242)	.946
1/T(DET)2	10.7	.0517	13.4	4.82	.0491	(.0295)	4.58	7.16	(.0295)	5.88
Z(DET)1	.338	(1.89)	.474	.188	(1.53)	.951	.262	.378	.622	.660
W(DET)1	.0514	(29.7)	.0309	.0355	(11.4)	2.62	.0218	.0147	1.87	.00734
NUMERATORS										
N(U /DS)										
A(U)	11.2	9.78	10.4	10.8	5.27	9.21	6.24	4.85	7.11	5.64
1/T(U)1	47.8	1.22	72.6	67.8	.247	.0926	.0795	.0840	.0386	.0548
1/T(U)2	(.849)	1.98	(.928)	(.926)	.996	.420	.741	.713	.221	.212
1/T(U)3	(.853)	78.1	(.739)	(.321)	109.	109.	212.	282.	159.	179.
N(W /DS)										
A(W)	-160.	-431.	-198.	-79.6	-166.	-63.1	-89.2	-126.	-27.1	-108.
1/T(W)1	48.6	79.7	73.3	68.1	109.	109.	212.	282.	159.	479.
Z(W)1	.299	.967	.394	.166	.876	.100	.261	[illegible]	-.0363	.830
W(W)1	.0555	.0310	.0367	.0367	.0124	.0309	.0160	.0117	.0184	.00552
N(THE/DS)										
A(THE)	-13.7	-37.6	-17.3	-7.02	-15.5	-5.96	-9.80	-12.3	-2.85	-8.79
1/T(THE)1	.0344	.0600	.0253	.0138	.0226	.00218	.00688	.00919	-.00270	.00999
1/T(THE)2	.881	1.52	.738	.334	.498	.210	.251	.267	.116	.111
N(HD /DS)										
A(HD)	161.	431.	198.	80.3	166.	63.3	89.4	126.	28.0	109.
1/T(HD)1	.0270	.0586	.0256	.00439	.0209	-.00661	.00482	.00833	-.0121	[illegible]
1/T(HD)2	-6.03	-10.0	-6.87	-4.46	-6.98	-4.47	-7.13	-8.52	-3.90	-7.21
1/T(HD)3	6.92	11.8	7.75	4.93	7.69	4.74	7.32	8.75	3.99	7.32
N(AZP/DS)										
A(AZP)	98.0	276.	128.	52.4	125.	48.9	95.0	104.	26.6	57.7
1/T(AZP)1	-.00446	-.000827	-.00217	-.00711	-.00157	.00116	-.00134	-.000451	-.00155	-.000297
1/T(AZP)2	.0312	.0593	.0276	.0110	.0223	-.00789	.00605	.00873	-.0100	.00872
Z(AZP)1	.0540	.0411	.0286	.0141	.0135	.0148	.0224	.0166	.0210	.00597
W(AZP)1	8.28	13.6	9.10	5.83	6.44	5.32	7.04	9.53	4.21	9.94

TABLE V-5

X-15 LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS Off

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	90 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
STICK FIXED										
D(G)/D(U) (DEG/KT)	-.0812	-.176	-.0769	-.0132	-.0629	.0198	-.0145	-.0250	.0362	-.0255
NZA (G/RAD)	15.0	41.2	18.9	7.92	17.8	7.37	15.0	24.0	5.32	20.2
DE/G (DEG/G)	1.96	.487	1.47	4.54	2.41	7.71	5.10	3.11	11.5	1.55
CAP (RAD/SEC/SEC/G)	.471	.320	.445	.556	.552	.801	.872	.666	.574	.238
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	(14.8)	--	--	--	--	--
1/C(1/10)	1.02	1.44	.846	.557	.539	.287	.185	.187	.133	.141

TABLE V-6

X-15 LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
YV	-.357	-.571	-.304	-.137	-.241	-.0951	-.127	-.163	-.0414	-.0997
YB	-199.	-510.	-252.	-106.	-279.	-110.	-246.	-474.	-64.8	-565.
LB'	-12.4	-1.96	-11.7	-16.3	-8.76	-5.33	-2.36	16.6	-12.3	-20.1
NB'	10.4	31.0	13.7	4.89	15.1	5.21	11.1	15.7	1.76	11.2
LP'	-2.54	-3.93	-2.09	-1.16	-1.60	-.738	-1.02	-1.08	-.448	-.507
NP'	.0129	-.00884	-.00862	-.0139	-.0198	-.000503	-.00735	-.0188	.00998	-.0195
LR'	-.184	-.170	-.0830	-.0353	-.245	.0570	.103	-.131	.164	.261
NR'	-.576	-1.05	-.513	-.219	-.356	-.149	-.196	-.251	-.0727	-.106
Y*DA	-.0274	-.0461	-.0217	-.00896	-.0120	-.00353	-.00498	-.00543	-.000840	-.00157
L'DA	35.2	113.	52.2	21.1	46.5	17.8	28.7	42.3	8.05	33.0
N'DA	1.59	4.85	2.09	.778	1.46	.403	.993	1.08	.0579	1.13
Y*DV	.137	.224	.113	.0509	.0821	.0326	.0426	.0503	.0143	.0241
L'DV	5.87	15.0	6.60	2.55	11.9	4.21	5.38	6.88	1.20	-6.54
N'DV	-5.81	-14.9	-7.09	-2.97	-7.50	-2.88	-6.90	-11.7	-1.81	-12.2

X-15 AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.69	6.00
DENOMINATOR										
1/T(DET)1	.0149	.00132	.00734	.0176	.00608	-.000447	-.00215	-.00188	.00863	-.000957
1/T(DET)2	2.46	3.93	2.06	.991	1.59	.679	1.01	1.09	.207	.503
Z(DET)1	.148	.144	.110	.0957	.0754	.0623	.0503	.0524	.0792	.0302
W(DET)1	3.36	5.63	3.80	2.64	3.96	2.63	3.35	3.89	2.19	3.50
NUMERATORS										
N(B /DA)										
A(B)	-.0274	-.0461	-.0217	-.00856	-.0120	-.00353	-.00498	-.00543	-.000840	-.00157
1/T(B)1	-27.3	-.347	-26.3	-229.	-93.2	-615.	-202.	-98.7	-2366.	.0479
1/T(B)2	(-.560)	5.43	(-.306)	(.705)	(.531)	(.734)	(.121)	(.986)	(.665)	.727
1/T(B)3	(1.25)	49.2	(1.35)	(.306)	(.634)	(.185)	(.308)	(.466)	(.0700)	-380.
N(P /DA)										
A(P)	35.2	113.	52.2	21.1	46.5	17.8	28.7	42.3	8.05	33.0
1/T(P)1	-.00396	-.000803	-.00201	-.00555	-.00154	-.00403	-.00116	-.000425	-.00539	-.000287
Z(P)1	.140	.143	.109	.0783	.0754	.0544	.0490	.0523	.0456	.0314
W(P)1	3.34	5.63	3.78	2.34	3.93	2.30	3.34	3.92	1.34	3.45
N(R /DA)										
A(R)	1.59	4.85	2.09	.778	1.46	.403	.993	1.08	.0979	1.13
1/T(R)1	.895	1.95	.770	.310	.501	.190	.239	.289	.0786	.105
Z(R)1	.207	.279	.150	.0615	.0559	.0493	.0677	.0152	.110	-.0111
W(R)1	3.96	3.67	4.22	4.45	5.20	5.83	4.74	4.78	8.07	4.27
N(PHI /DA)										
A(PHI)	35.3	114.	52.3	21.2	46.6	17.9	28.8	42.3	8.07	33.1
Z(PHI)1	.141	.144	.109	.0772	.0753	.0534	.0490	.0522	.0434	.0312
W(PHI)1	3.34	5.63	3.78	2.36	3.93	2.32	3.35	3.92	1.38	3.45
N(AYP/DA)										
A(AYP)	91.9	300.	136.	54.1	116.	42.7	72.2	97.6	17.5	84.7
1/T(AYP)1	-.387	-.344	-.335	.196	.219	.136	.157	.107	1.31	.0383
1/T(AYP)2	.606	.696	.408	-.376	-.325	-.296	-.192	-.360	-1.41	-.396
Z(AYP)1	.154	.138	.114	.118	.0823	.0997	.0591	.0680	.920	.0777
W(AYP)1	3.33	5.52	3.79	2.31	3.95	2.19	3.27	3.80	.159	3.08

TABLE V-8

X-15 VERTICAL STABILIZER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.900	.800	1.20	1.20	2.00	3.00	1.60	6.00
DENOMINATOR										
1/T(DET)1	.0149	.00132	.00734	.0176	.00608	-.000447	-.00216	-.00185	.00863	-.000987
1/T(DET)2	2.46	3.93	2.06	.971	1.59	.679	1.01	1.09	.207	.503
Z(DET)1	.148	.144	.110	.0957	.0754	.0623	.0503	.0524	.0792	.0307
W(DET)1	3.36	5.63	3.80	2.64	3.96	2.43	3.35	3.89	2.19	3.50
NUMERATORS										
N(B /DV)										
A(B)	.137	.224	.113	.0509	.0821	.0326	.0425	.0503	.0143	.0241
1/T(B)1	.0128	.0101	.00807	.00215	.0117	.00181	-.000352	.00237	-.0110	-.00393
1/T(B)2	2.45	3.90	2.05	1.10	1.56	.656	.989	1.08	.348	.435
1/T(B)3	45.9	65.1	66.2	64.7	59.8	106.	171.	237.	144.	492.
N(P /DV)										
A(P)	5.87	15.0	6.60	2.55	11.9	4.21	5.38	6.88	1.20	-6.54
1/T(P)1	-.00417	-.000802	-.00193	-.00561	-.00154	-.00402	-.00115	-.000428	-.00540	-.000297
Z(P)1	(-.988)	.162	.319	(-3.70)	.111	.0673	.0304	.0572	(3.00)	.0550
W(P)1	(1.82)	5.45	1.11	(3.78)	3.11	1.24	2.84	6.62	(-4.17)	6.98
N(R /DV)										
A(R)	-5.81	-14.9	-7.09	-2.97	-7.50	-2.88	-6.90	-11.7	-1.81	-12.8
1/T(R)1	2.49	-.510	-.112	.365	.352	.157	.190	.255	.0790	.106
Z(R)1	.356	(.513)	(.179)	.367	(-.612)	(-.393)	(-.417)	(-.691)	.116	.201
W(R)1	.208	(4.04)	(2.12)	1.17	(1.96)	(1.01)	(1.31)	(1.63)	1.68	1.16
N(PHI/DV)										
A(PHI)	5.46	14.7	6.23	2.15	11.5	3.79	4.90	6.44	.724	-7.18
Z(PHI)1	(-1.10)	.155	.271	(4.04)	.103	.0361	.0135	.0530	(4.99)	.0563
W(PHI)1	(1.79)	5.51	1.14	(-4.19)	3.17	1.32	2.98	6.85	(-5.77)	6.67
N(AYP/DV)										
A(AYP)	-19.8	-46.9	-24.9	-10.7	-19.4	-7.07	-35.5	-58.0	-9.07	-103.
1/T(AYP)1	.00785	.0492	.0100	-.0278	.0238	.00545	.00159	.00518	-.0208	-.00486
1/T(AYP)2	2.60	6.05	2.27	.620	2.69	.787	1.17	1.42	.215	.418
Z(AYP)1	-.0739	-.498	-.0937	.0724	-.0924	.0224	-.00935	-.0362	.0630	.00843
W(AYP)1	4.28	4.47	4.37	4.51	4.70	4.16	4.44	6.67	4.25	7.78

TABLE V-9

X-15 AILERON TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.800	.800	1.70	1.20	2.00	3.00	1.60	6.00
DENOMINATOR										
1/T(DET)1	-.0464	-.0329	-.0343	-.0315	-.0277	-.0312	-.0173	-.0131	-.00528	-.00250
1/T(DET)2	19.3	58.2	27.1	11.1	24.0	9.30	14.8	21.6	3.58	16.4
Z(DET)1	.419	.556	.408	.322	.390	.298	.385	.518	.507	.504
W(DET)1	3.37	5.75	3.81	2.33	3.93	2.21	3.32	2.94	1.51	3.42
NUMERATORS										
N(B /DA)										
A(B)	-.0274	-.0461	-.0217	-.00856	-.0120	-.00353	-.00498	-.00543	-.000840	-.00157
1/T(B)1	-33.3	3.02	1.14	.362	.557	.210	.273	.293	.0867	.102
1/T(B)2	(.854)	-3.23	6.23	1.33	5.26	1.12	3.94	10.4	.580	10.7
1/T(B)3	(2.31)	51.9	-35.6	-230.	-99.1	-617.	-207.	-108.	-2266.	-392.
N(P /DA)										
A(P)	35.2	113.	52.2	21.1	46.5	17.8	28.7	42.3	8.05	33.0
1/T(P)1	-.00388	-.000790	-.00198	-.00554	-.00152	-.00400	-.00115	-.000416	-.00533	-.000281
Z(P)1	.410	.553	.397	.273	.374	.248	.365	.590	.248	.547
W(P)1	3.37	5.67	3.81	2.35	3.95	2.31	3.36	3.96	1.35	3.49
N(R /DA)										
A(R)	1.59	4.85	2.09	.778	1.46	.403	.993	1.08	.0579	1.13
1/T(R)1	.895	1.95	.770	.310	.501	.190	.239	.289	.0786	.105
Z(R)1	.267	.279	.150	.0619	.0559	.0493	.0677	.0152	.110	-.0111
W(R)1	3.96	3.67	4.22	4.45	5.20	5.83	4.74	4.78	8.07	4.27
N(PHI/DA)										
A(PHI)	35.3	114.	52.3	21.2	46.6	17.9	28.8	42.3	8.07	33.1
Z(PHI)1	.409	.553	.397	.270	.373	.245	.364	.500	.239	.546
W(PHI)1	3.37	5.67	3.81	2.36	3.96	2.33	3.36	3.96	1.39	3.49
N(AYP/DA)										
A(AYP)	91.9	300.	136.	54.1	116.	42.7	72.2	97.6	17.5	84.7
1/T(AYP)1	-.635	-.533	.488	.239	.312	.164	.208	.228	.0836	.0967
1/T(AYP)2	.668	.820	-.375	-.670	-.656	-.672	-.744	-1.21	-1.65	-1.45
Z(AYP)1	.412	.522	.389	.334	.374	.342	.399	.523	.827	.597
W(AYP)1	3.46	5.58	3.90	2.46	4.10	2.38	3.52	4.35	1.39	4.38

TABLE V-10

X-15 VERTICAL STABILIZER TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
DENOMINATOR										
1/T(DET)1	-.0464	-.0328	-.0343	-.0315	-.0277	-.0312	-.0173	-.0131	-.00528	-.00250
1/T(DET)2	19.3	58.2	27.1	11.1	24.0	9.30	14.8	21.6	3.58	16.4
Z(DET)1	.419	.556	.408	.322	.390	.298	.385	.518	.507	.564
W(DET)1	3.37	5.75	3.81	2.33	3.93	2.21	3.32	3.94	1.51	3.52
NUMERATORS										
N(B /DV)										
A(B)	.137	.224	.113	.0509	.0821	.0326	.0426	.0503	.0143	.0241
1/T(B)1	-.0492	-.0304	-.0348	-.0428	-.0250	-.0300	-.0160	-.0101	-.0286	-.00544
1/T(B)2	17.5	56.9	25.6	9.37	22.1	7.11	14.0	21.2	2.99	16.4
1/T(B)3	49.0	73.6	69.1	67.2	103.	109.	172.	239.	146.	492.
N(P /DV)										
A(P)	5.87	15.0	6.60	2.55	11.9	4.21	5.38	6.88	1.20	-6.54
1/T(P)1	-.00206	-.00100	.00252	-.00536	-.00173	-.00474	-.00133	-.000458	-.00534	-.000275
1/T(P)2	.239	-.469	.0371	1.17	-.691	-.250	-.427	-1.33	2.09	1.95
1/T(P)3	-15.8	-50.6	-25.5	-12.5	-12.4	-5.26	-16.4	-30.6	-7.86	26.1
N(R /DV)										
A(R)	-5.81	-14.9	-7.09	-2.97	-7.50	-2.88	-6.90	-11.7	-1.81	-12.2
1/T(R)1	20.9	-.0386	-.0147	11.9	-.107	-.0770	-.0670	-.0898	.0863	16.6
Z(R)1	.811	(.189)	(.0987)	.448	(.151)	(.0810)	(.0983)	(.141)	(.687)	.857
W(R)1	.0719	(63.1)	(29.2)	.204	(26.1)	(9.98)	(15.8)	(22.6)	(3.74)	.0927
N(PHI/DV)										
A(PHI)	5.46	14.7	6.23	2.15	11.5	3.79	4.90	6.44	.724	-7.18
1/T(PHI)1	.219	-.455	.0423	1.06	-.639	-.211	-.391	-1.26	2.01	1.85
1/T(PHI)2	-18.5	-53.2	-28.7	-16.8	-13.9	-7.03	-19.7	-34.5	-14.5	25.2
N(AYP/DV)										
A(AYP)	-19.8	-46.9	-24.9	-10.7	-19.4	-7.07	-35.5	-58.0	-9.07	-103.
1/T(AYP)1	-.0508	-.0289	-.0351	-.0465	-.0243	-.0298	-.0159	-.00994	-.0298	-.00547
1/T(AYP)2	44.9	149.	62.4	24.2	80.4	30.0	26.7	36.1	4.86	17.7
Z(AYP)1	-.0560	-.206	-.0680	.119	-.0320	.0670	.0242	.0106	.492	.0515
W(AYP)1	2.82	3.61	3.01	2.19	3.26	2.24	3.51	5.79	2.50	6.56

TABLE V-11

X-15 LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	90 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
DR PERIOD (SEC)	1.89	1.13	1.67	2.39	1.59	2.59	1.88	1.62	2.88	1.79
1/C(1/2)	1.36	1.32	1.01	.671	.685	.566	.456	.476	.720	.274
SPIRAL (2) (SEC)	--	--	--	--	--	1550.	321.	375.	--	702.
P(1)	13.6	28.8	24.5	15.8	28.2	23.0	--	39.5	3.99	--
P(2)	--	--	--	14.7	--	22.5	--	--	2.96	--
P(3)	--	--	--	15.6	--	23.0	--	--	8.59	--
P(2)/P(1)	--	--	--	.929	--	.982	--	--	.742	--
P(DSC)/P(AV)	--	--	--	.0326	--	.0101	--	--	.360	--
W(PHI)/W(D)	.993	1.00	.997	.894	.994	.954	.998	1.01	.631	.985
DEL-B-MAX	.0324	.132	.0384	.398	.100	.543	.153	.0631	.685	.104
PHI TO BETA, PHASE	22.3	-3.41	17.5	14.2	9.05	13.9	30.0	191.	3.58	7.48
PHI TO BETA	.888	.0391	.699	2.14	.484	.755	.144	1.11	2.46	1.58
PHI TO VE	.0911	.00251	.0662	.318	.0480	.121	.0139	.0709	.472	.0809

X-15 DATA SOURCES

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SECTION VI

HL-10

HL-10 BACKGROUND

The HL-10 is one of a number of lifting body research vehicles. The airplane is typically launched from a B-52 at 0.8 Mach and 45,000 feet. In numerous glide and powered flights the HL-10 has been flown in excess of 1.8 Mach and 90,000 feet.

Following problems involving the loss of roll-control effectiveness, the leading edge of the tip fins was modified. This became known as the Mod II configuration. The information contained here is for the Mod II HL-10.

Pitch and roll control is obtained by elevons and yaw control by a conventional rudder. A subsonic or a transonic configuration is selected using combinations of speed brakes, elevon flaps, and tip fin flaps. These combinations are specified in Fig. VI-1.

The stability augmentation system consists of angular rate feedback loops about all three axes.

The flight conditions shown correspond to actual flight test points.

HL-10

Nominal Configuration

Zero fuel (burnout)

Gear up

Transonic or subsonic configuration depending upon flight condition

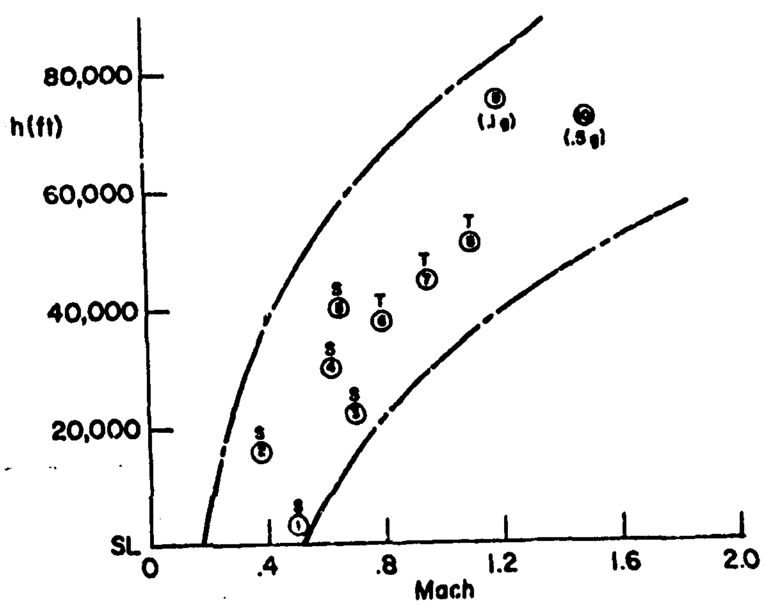
W = 6466 lb

c.g. at .517 $\bar{c}$, W.L. 94.4

I_x = 1353 slug-ft^2
I_y = 6413 slug-ft^2
I_z = 7407 slug-ft^2
I_{xz} = 399 slug-ft^2

Body Axis

Flight Envelope



Nominal Envelope Extremes

Transfer Function Case n
(S ≈ Subsonic, T ≈ Transonic)

Note:

Configuration	Speed Brakes	Elevon Flaps	Tip-Fin Flaps
Subsonic	Zero	Zero	Zero
Transonic	8°	30°	30.5°/32.5°

Figure VI-1. HL-10 Flight Conditions

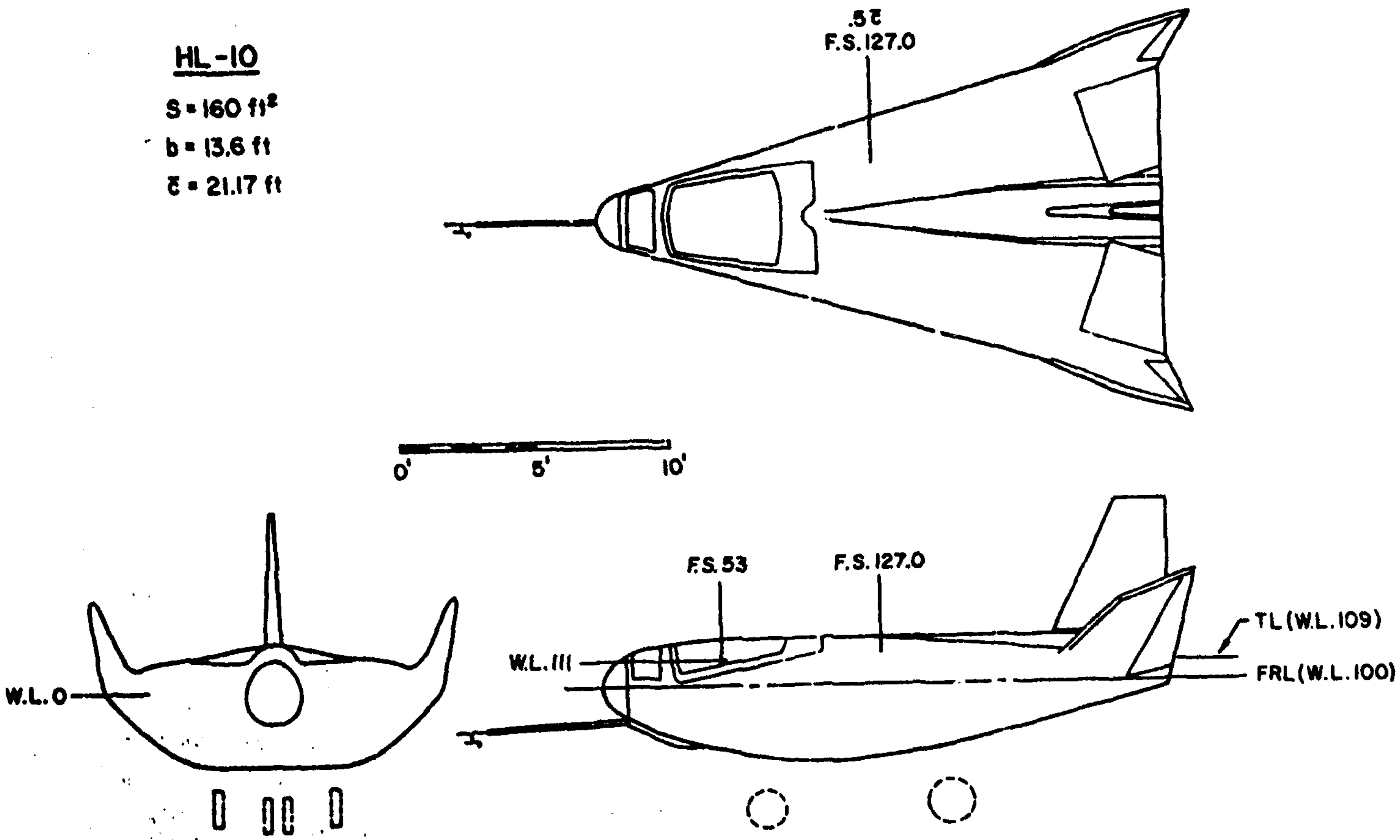


Figure VI-2. HL-10 General Arrangement

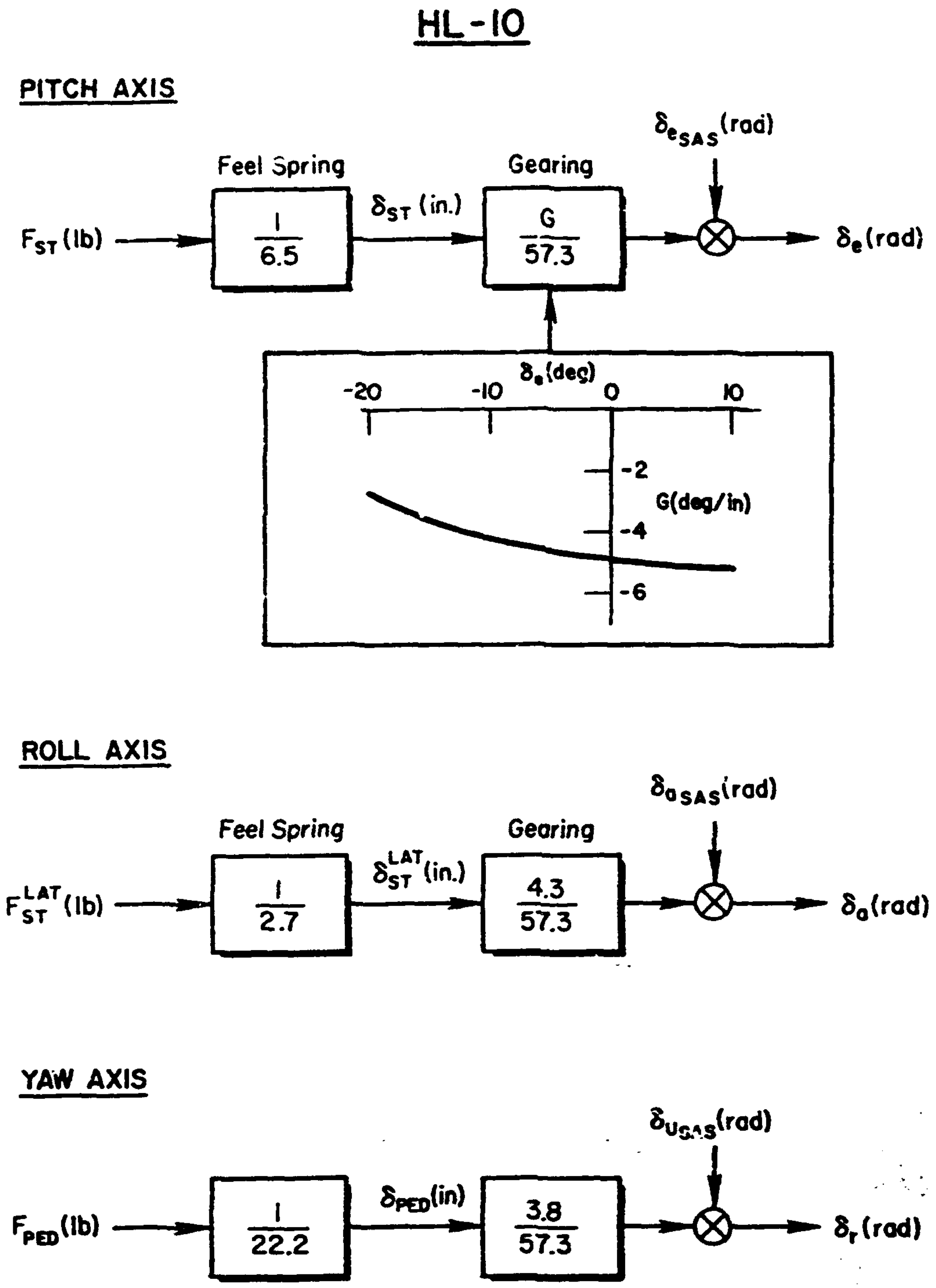


Figure VI-3. HL-10 Control System

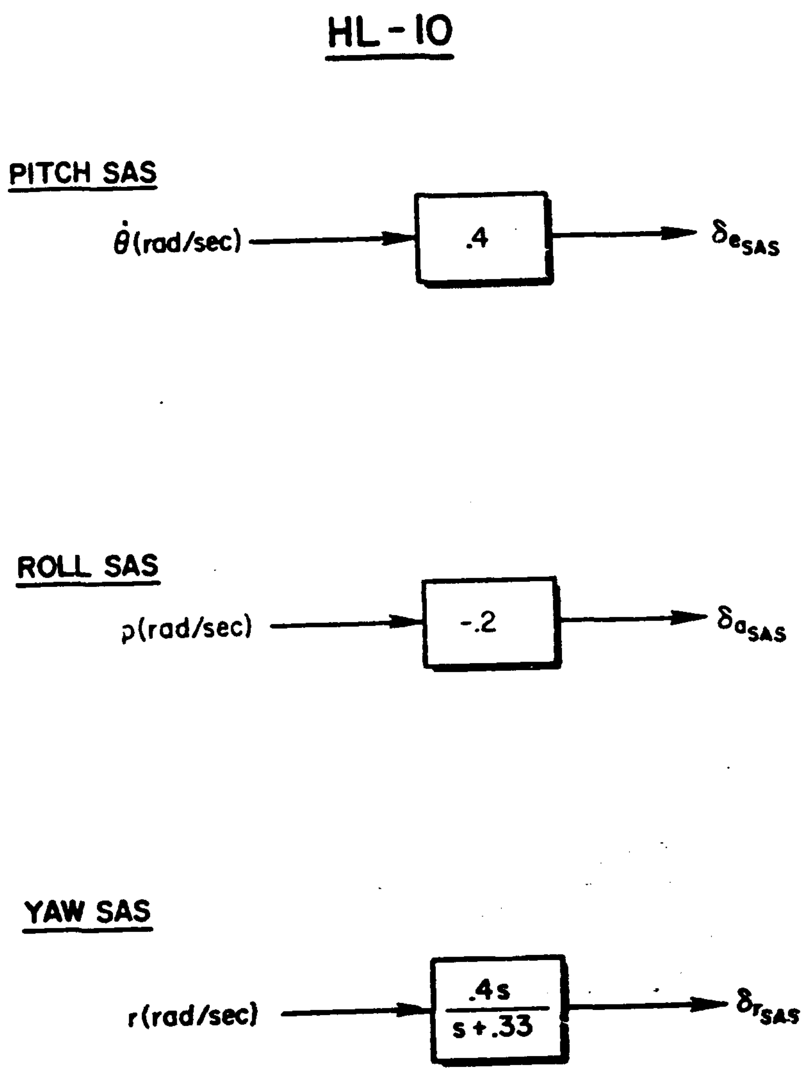
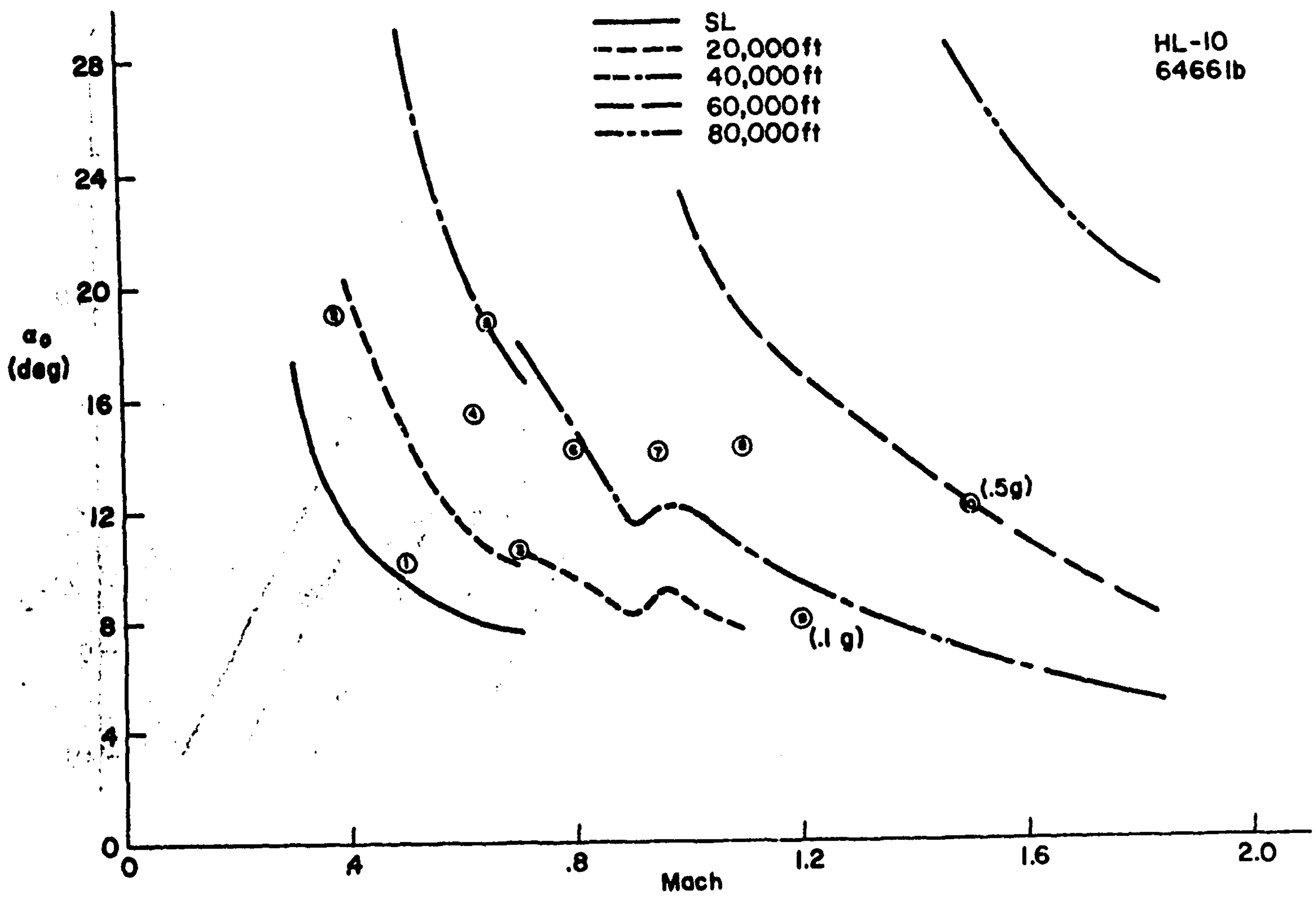
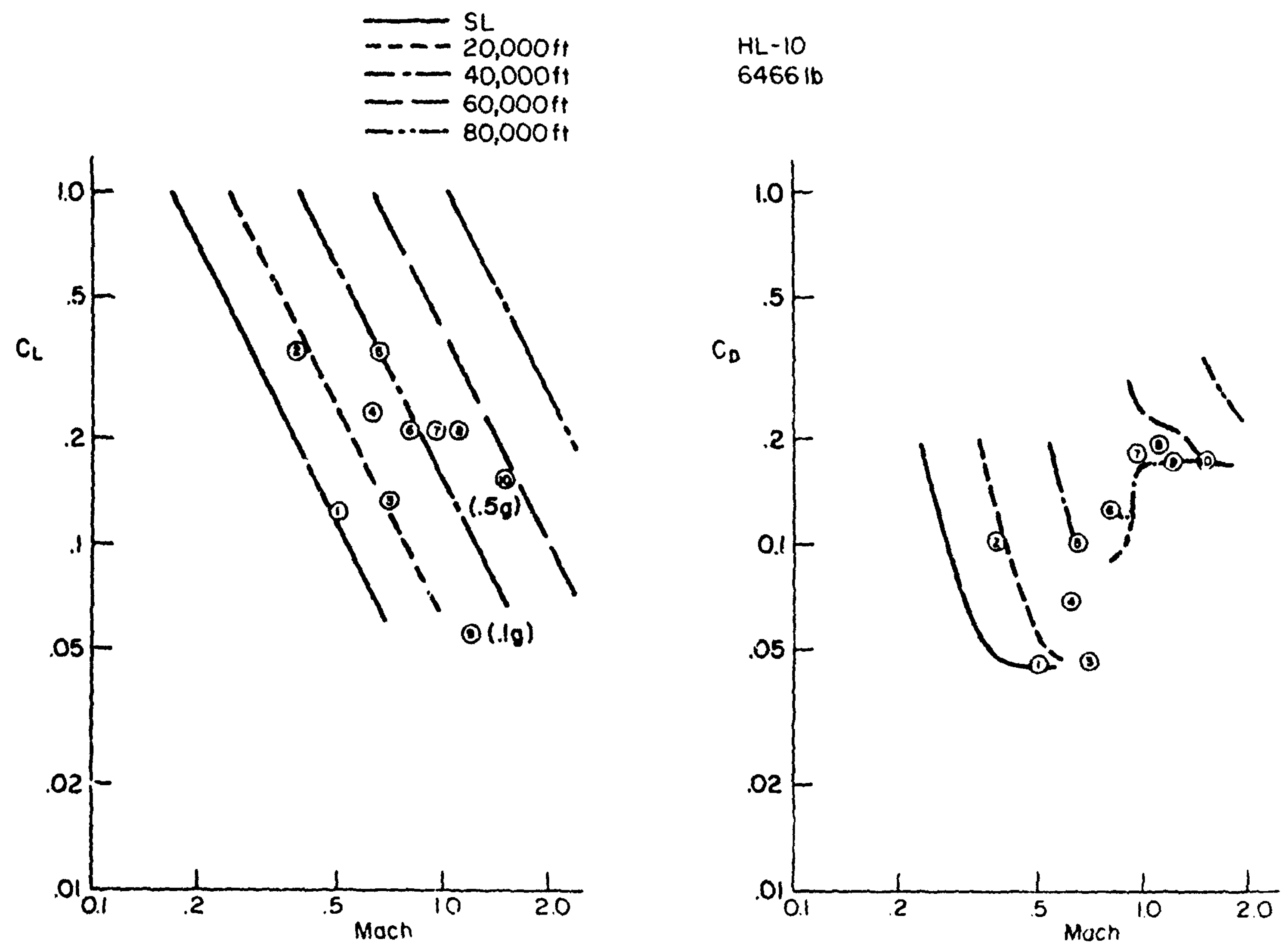
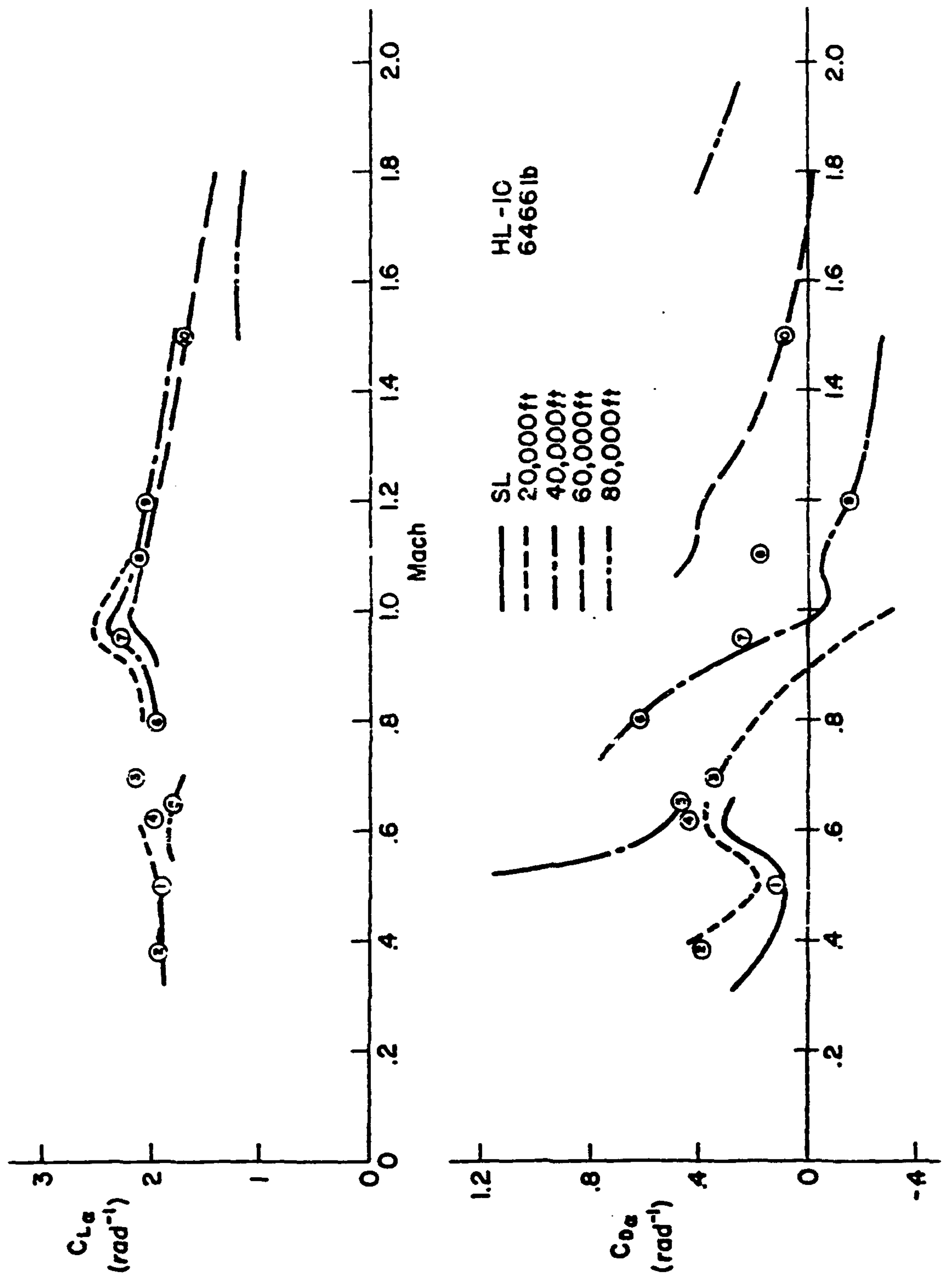


Figure VI-4. HL-10 Stability Augmentation

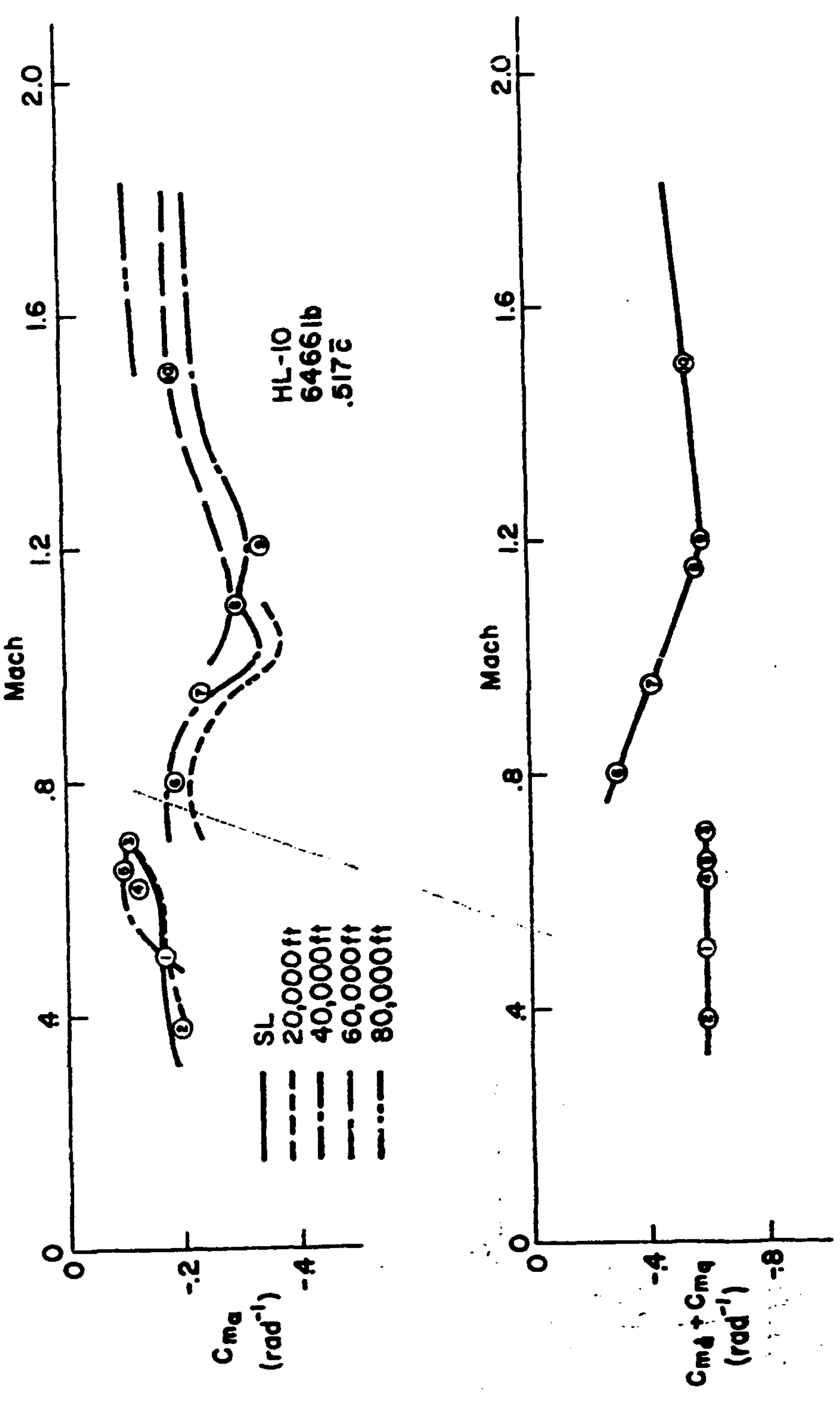


SL
20,000ft
40,000ft
60,000ft
80,000ft
HL-10
6466lb
(.5g)
(.1 g)
α_o
(deg)
28
24
20
16
12
8
4
0
0
.4
.8
1.2
1.6
2.0
Mach

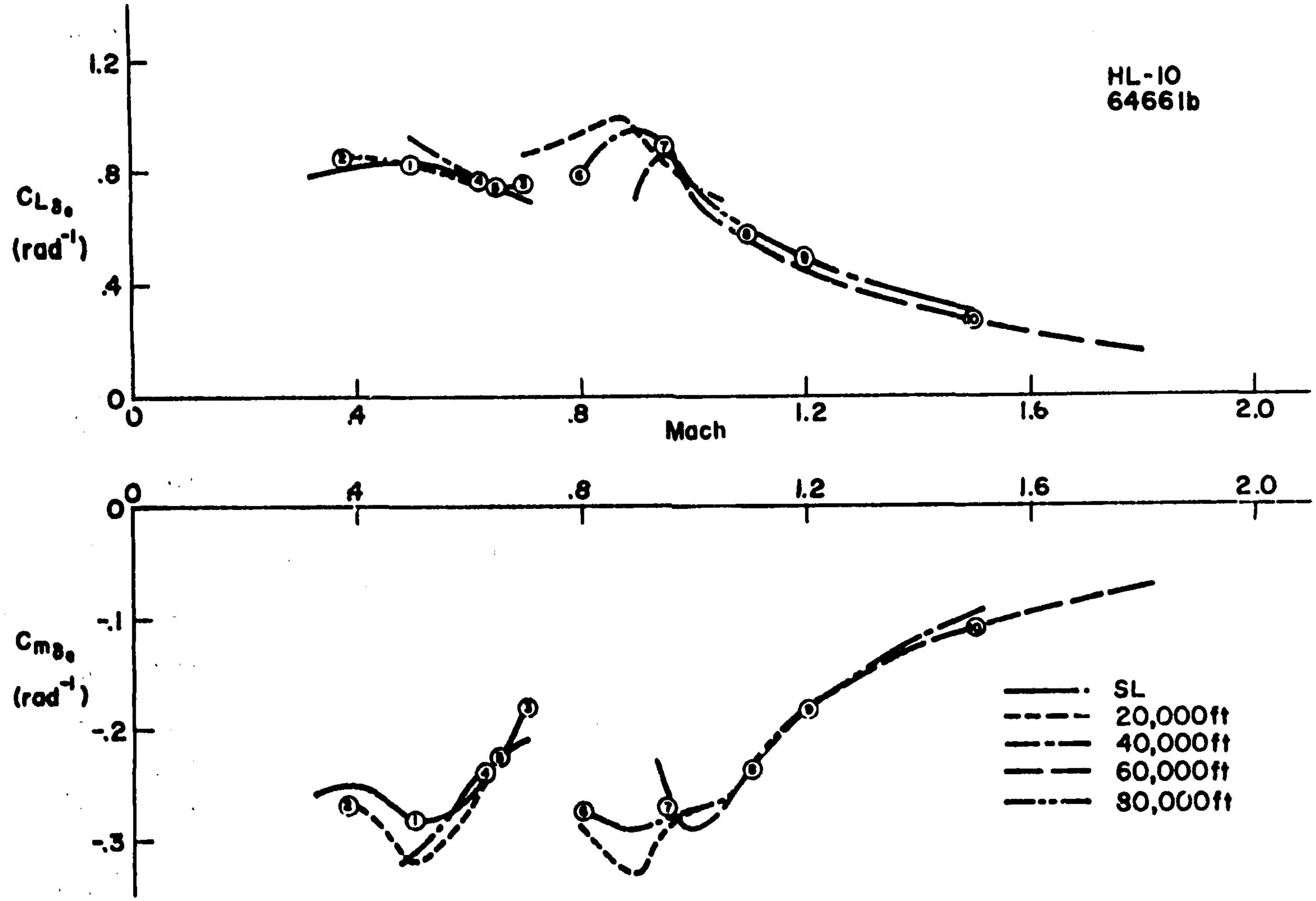

SL
20,000 ft
40,000 ft
60,000 ft
80,000 ft
HL-10
6466 lb
C_L
C_D
Mach
Mach
(.5g)
(.1g)
1.0
.5
.2
.1
.05
.02
.01
0.1
.2
.5
1.0
2.0

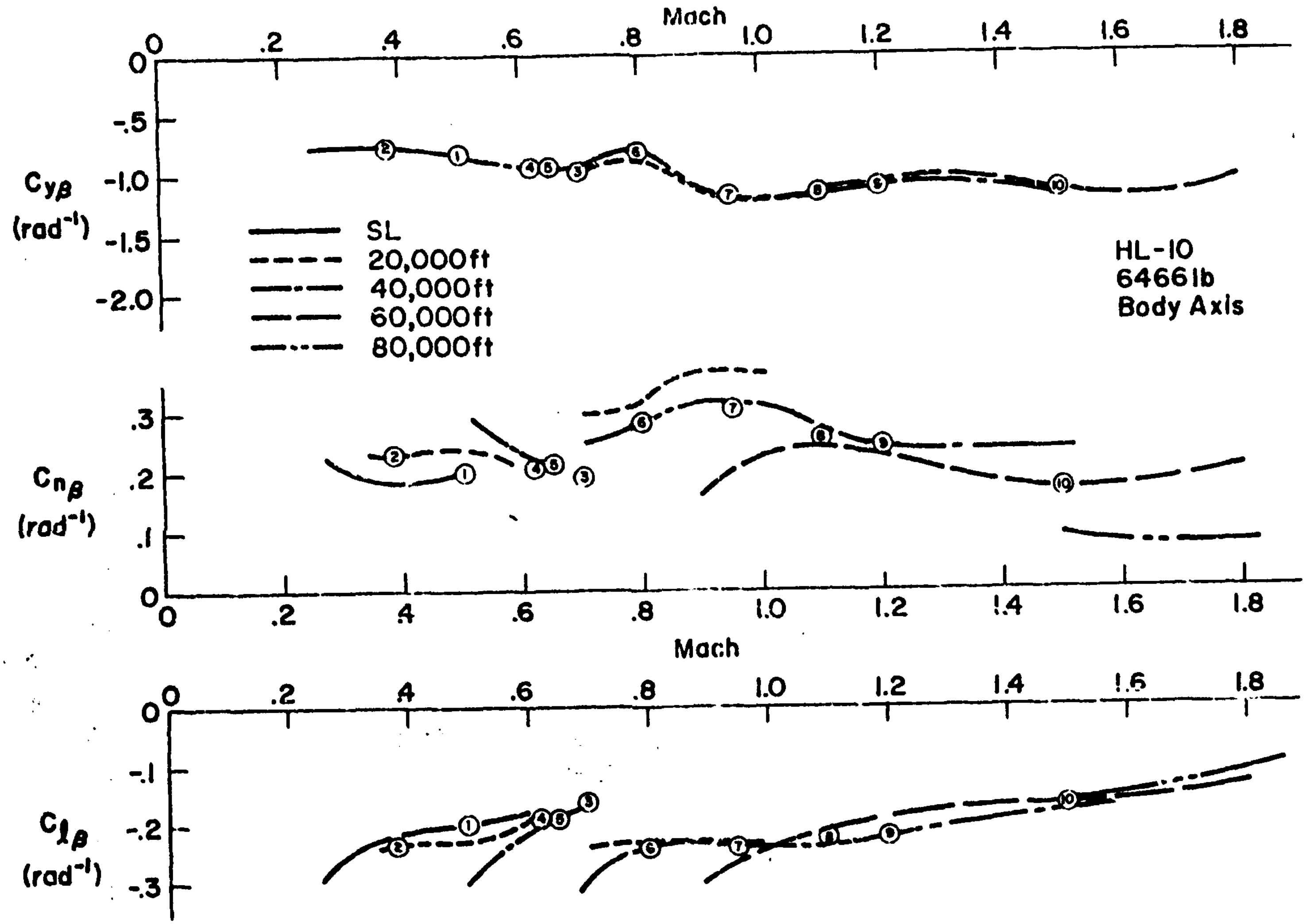


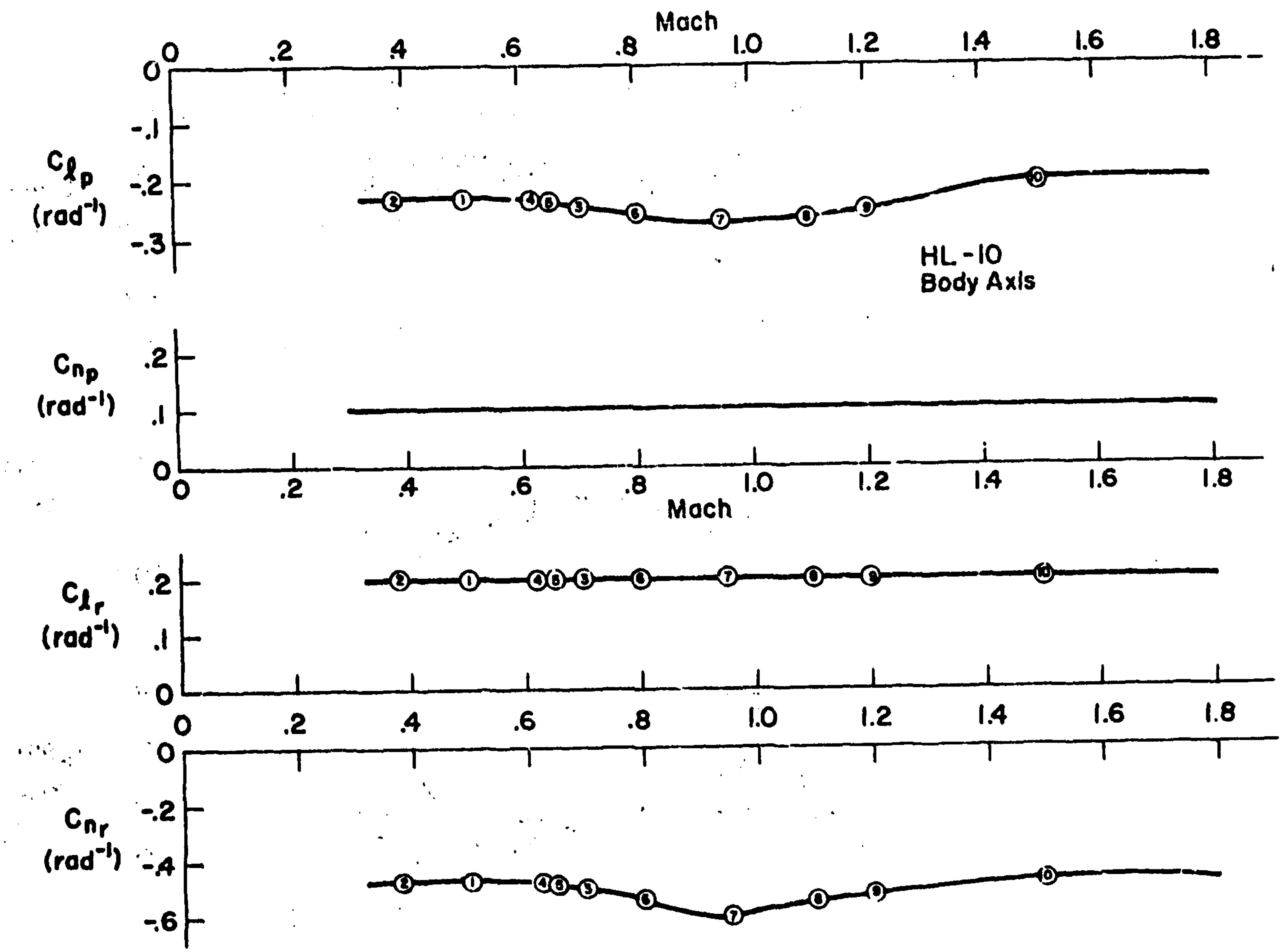
$C_{L\alpha}$ (rad^{-1})
$C_{D\alpha}$ (rad^{-1})
Mach
SL
20,000ft
40,000ft
60,000ft
80,000ft
HL-10
64661b



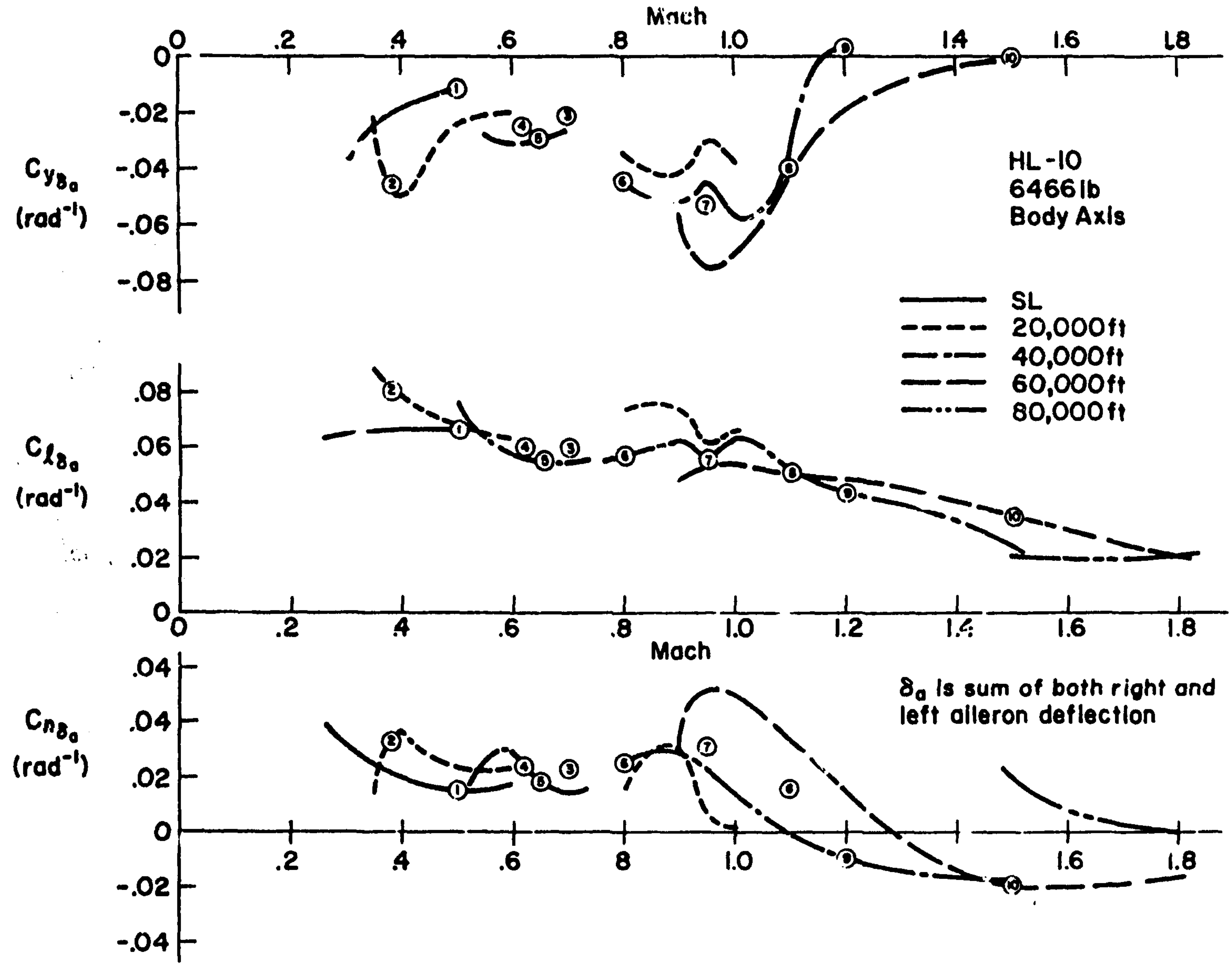
HL-10
6466lb
.517c̄
SL
20,000ft
40,000ft
60,000ft
80,000ft
Mach
0
.4
.8
1.2
1.6
2.0
-.2
-.4
Cmα (rad⁻¹)
-.4
-.8
Cmα̇ + Cmq (rad⁻¹)


HL-10
6466 lb
$C_{L_{\delta_e}}$
(rad^{-1})
1.2
.8
.4
0
0
.4
.8
1.2
1.6
2.0
Mach
$C_{m_{\delta_e}}$
(rad^{-1})
0
-.1
-.2
-.3
SL
20,000ft
40,000ft
60,000ft
80,000ft


Mach
$C_{y\beta}$ (rad^{-1})
$C_{n\beta}$ (rad^{-1})
$C_{l\beta}$ (rad^{-1})
SL
20,000ft
40,000ft
60,000ft
80,000ft
HL-10
6466lb
Body Axis



Mach
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
C_{l_p} (rad^{-1})
-.1
-.2
-.3
HL-10
Body Axis
C_{n_p} (rad^{-1})
.2
.1
C_{l_r} (rad^{-1})
C_{n_r} (rad^{-1})
-.4
-.6



Mach
HL-10
6466 lb
Body Axis
SL
20,000 ft
40,000 ft
60,000 ft
80,000 ft
$C_{y_{\delta_a}}$ (rad^{-1})
$C_{l_{\delta_a}}$ (rad^{-1})
$C_{n_{\delta_a}}$ (rad^{-1})
δ_a is sum of both right and left aileron deflection

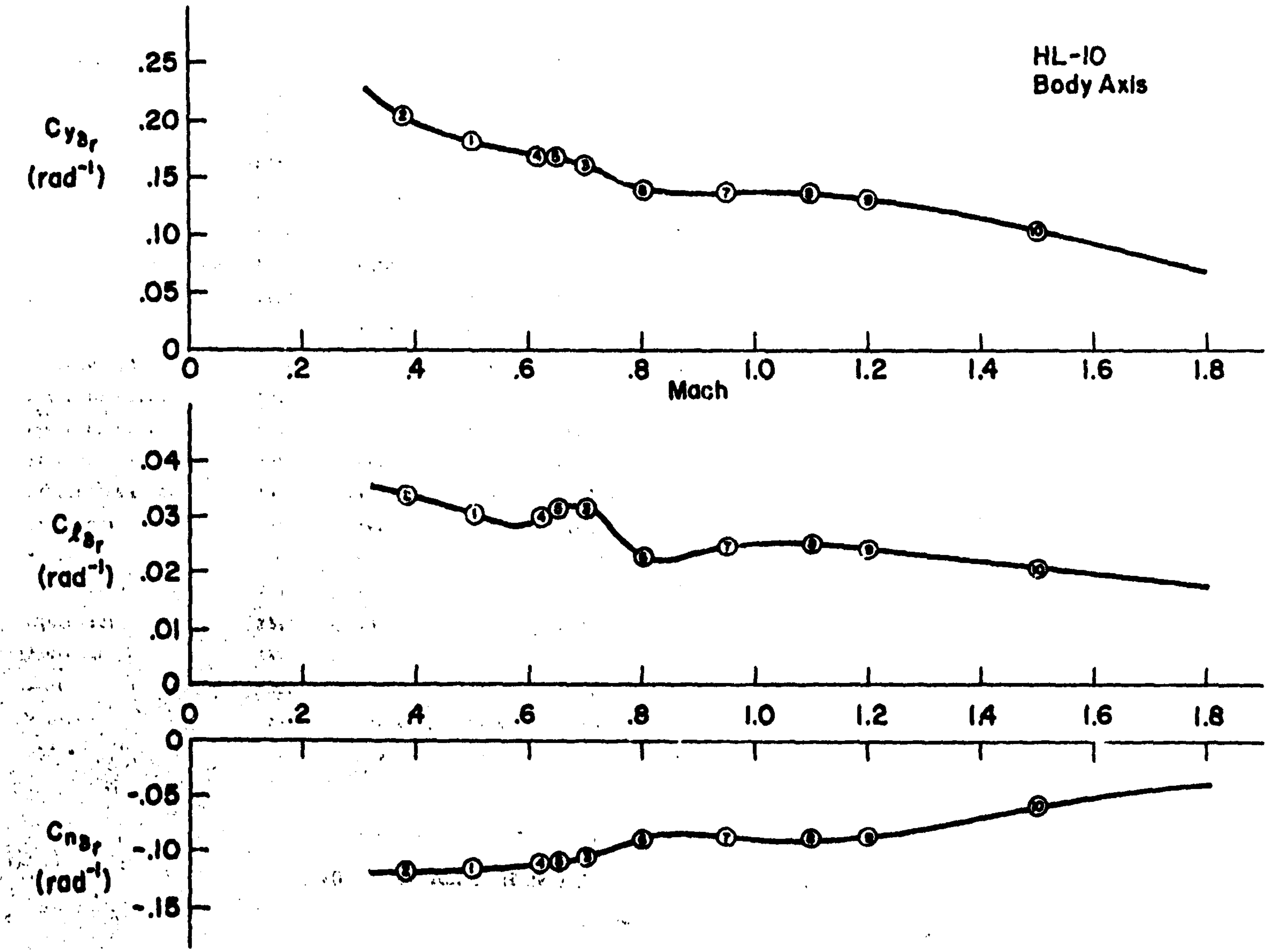

HL-10
Body Axis
$C_{y_{\delta_r}}$ (rad^{-1})
$C_{\ell_{\delta_r}}$ (rad^{-1})
$C_{n_{\delta_r}}$ (rad^{-1})
Mach

TABLE VI-1

HL-10 DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

$s = 160.0$ sq ft, $b = 13.60$ ft, $\bar{c} = 21.17$ ft

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M(-)	.500	.380	.700	.62C	.650	.800	.950	1.10	1.20	1.50
VTO(FPS)	552.	400.	720.	617.	629.	774.	920.	1064.	1169.	1458.
VTO(KTAS)	327.	237.	427.	365.	373.	459.	545.	631.	693.	864.
VTO(KCAS)	313.	187.	311.	231.	193.	254.	263.	273.	175.	244.
W(LBS)	6466.	6466.	6466.	6466.	6466.	6466.	6466.	6466.	6466.	6466.
C.G.(MGC)	.517	.517	.517	.517	.517	.517	.517	.517	.517	.517
IX (SLUG-FT SQ)	1353.	1353.	1353.	1353.	1353.	1353.	1353.	1353.	1353.	1353.
IY (SLUG-FT SQ)	6413.	6413.	6413.	6413.	6413.	6413.	6413.	6413.	6413.	6413.
IZ (SLUG-FT SQ)	7407.	7407.	7407.	7407.	7407.	7407.	7407.	7407.	7407.	7407.
IXZ(SLUG-FT SQ)	399.	399.	399.	399.	399.	399.	399.	399.	399.	399.
EPSILCN(DEG)	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75
Q(PSF)	329.	116.	307.	169.	117.	194.	196.	197.	75.3	136.
QC(PSF)	351.	120.	346.	186.	129.	228.	244.	264.	105.	208.
ALPHA(DEG)	10.2	19.0	10.6	15.5	18.8	14.2	14.1	14.2	8.00	12.0
GAMMA(DEG)	-32.0	-14.0	-26.0	-26.C	-23.0	-25.0	-26.0	-35.0	-15.0	14.0
LXP(FT)	6.50	6.50	6.50	6.5C	6.50	6.50	6.50	6.50	6.50	6.50
LZP(FT)	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40
ITH(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LTH(FT)	-1.20	-1.20	-1.20	-1.2C	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20

TABLE VI-2

HL-10 LONGITUDINAL DIMENSIONAL DERIVATIVES

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	[illegible]	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
XU *	-.0509	-.0401	-.0260	-.0227	-.0191	-.0325	-.0648	-.0597	-.0200	-.0273
ZU *	.0383	-.0122	.0417	.0175	-.0143	.0128	.0182	.00842	.00754	.000762
MU *	.00463	.00596	.00225	.00217	.00136	.00400	.00479	.00478	.00130	.00258
XW	.164	.140	.0637	.0777	.0727	.0148	.0851	.0763	.0242	.0293
ZW	-.916	-.481	-.743	-.459	-.291	-.432	-.417	-.334	-.111	-.137
MW	-.0305	-.0166	-.0141	-.0102	-.00548	-.0139	-.0148	-.0162	-.00663	-.00493
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MQ	-.662	-.321	-.472	-.305	-.205	-.139	-.165	-.199	-.0714	-.0945
XDE	38.1	25.6	33.7	27.7	22.1	29.6	33.5	21.6	4.01	5.84
ZDE	-212.	-74.2	-180.	-98.7	-65.0	-117.	-133.	-85.3	-28.5	-27.5
MDE	-28.0	-9.51	-16.8	-12.3	-7.97	-14.2	-16.1	-14.2	-4.23	-4.53

TABLE VI-3

HL-10 ELEVATOR TRANSFER FUNCTION FACTORS

SAS Off

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
Z(DET)1	.469	.283	.403	.363	.333	.526	.618	.697	.609	.362
W(DET)1	.0760	.117	.0581	.0632	.0651	.0676	.0636	.0531	.0209	.0345
Z(DET)2	.186	.145	.184	.145	.125	.0794	.0751	.0610	.0316	.0418
W(DET)2	4.19	2.68	3.25	2.56	1.89	3.35	3.79	4.75	2.81	2.80
NUMERATORS										
N(U /DE)										
A(U)	38.1	25.6	33.7	27.7	22.1	29.6	33.5	21.6	4.01	5.84
1/T(U)1	72.3	48.6	66.1	73.7	73.0	.138	108.	172.	172.	235.
Z(U)1	.346	.536	.862	.599	.601	(.402)	.539	.467	.602	.447
W(U)1	.440	.298	.369	.265	.196	(104.)	.199	.158	.112	.106
N(W /DE)										
A(W)	-212.	-74.2	-180.	-98.7	-65.0	-117.	-133.	-85.3	-28.5	-27.5
1/T(W)1	.0158	48.8	-.0120	.00858	73.2	104.	108.	.0320	.00596	.00571
1/T(W)2	.0500	(.267)	.0422	.0151	(.369)	(.629)	(.991)	.0366	.0164	.0115
1/T(W)3	72.5	(.0690)	66.4	74.6	(.0378)	(.0296)	(.0341)	172.	172.	235.
N(THE/DE)										
A(THE)	-28.0	-9.51	-16.8	-12.5	-7.97	-16.2	-16.1	-14.2	-4.23	-4.53
1/T(THE)1	.0440	.0423	.0204	.0178	.0218	.0246	.0599	.0583	.0193	.0282
1/T(THE)2	.686	.334	.594	.378	.239	.332	.289	.231	.0661	.103
N(HD /DE)										
A(HD)	182.	74.2	165.	92.0	43.2	109.	123.	72.0	27.8	27.2
1/T(HD)1	.0650	.0207	.0325	.0269	.0199	.0292	.0632	.0647	.0215	.0167
1/T(HD)2	-6.69	-3.83	-6.16	-5.22	-4.07	-5.93	-5.50	-6.18	-3.31	-4.97
1/T(HD)3	7.34	4.18	6.60	5.51	4.28	6.06	5.67	6.37	3.38	5.07
N(AZP/DE)										
A(AZP)	-29.6	-12.4	-71.1	-18.5	-13.3	-11.5	-28.7	7.01	-1.00	1.98
1/T(AZP)1	.0218	-.0105	.0107	.00981	.00613	.00918	.00782	.0117	.00350	-.0108
1/T(AZP)2	.0445	.0301	.0229	.0179	.0142	.0218	.0571	.0552	.0186	.0256
Z(AZP)1	(-18.5)	(-9.66)	(-9.84)	(12.2)	(-5.18)	(17.8)	(11.9)	.0142	(-17.9)	.00687
W(AZP)1	(19.0)	(9.95)	(10.1)	(-12.3)	(5.26)	(-19.4)	(-12.2)	22.0	(18.1)	18.4

TABLE VI-4

HL-10 ELEVATOR TRANSFER FUNCTION FACTORS

SAS On

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
Z(DET)1	(2.42)	.267	(2.86)	.342	.315	.503	.629	.705	.610	.363
W(DET)1	(10.3)	.109	(5.06)	.0561	.0594	.0625	.0600	.0514	.0207	.0341
Z(DET)2	.485	.192	.391	.986	.883	.969	.872	.706	.331	.361
W(DET)2	.0636	2.90	.0497	2.88	2.07	3.63	4.01	4.39	2.83	2.83
NUMERATORS										
N(U /DE)										
A(U)	38.1	25.6	33.7	27.7	22.1	29.6	33.5	21.6	6.01	5.84
1/T(U)1	72.3	48.6	66.1	73.7	73.0	.138	108.	172.	172.	235.
Z(U)1	.346	.536	.862	.699	.601	(.402)	.539	.467	.602	.447
W(U)1	.440	.298	.369	.265	.196	(104.)	.199	.158	.112	.106
N(W /DE)										
A(W)	-212.	-74.2	-180.	-98.7	-65.0	-117.	-133.	-85.3	-29.5	-27.5
1/T(W)1	.0158	48.8	-.0120	.00839	73.2	104.	108.	.0320	.00596	.00571
1/T(W)2	.0500	(.267)	.0422	.0191	(.369)	(.629)	(.991)	.0366	.0164	.0115
1/T(W)3	72.5	(.0690)	66.4	74.6	(.0378)	(.0296)	(.0341)	172.	172.	235.
N(THE/DE)										
A(THE)	-28.0	-9.51	-16.8	-12.3	-7.97	-16.2	-16.1	-14.2	-4.23	-4.53
1/T(THE)1	.0440	.0423	.0204	.0178	.0218	.0246	.0599	.0583	.0193	.0202
1/T(THE)2	.686	.334	.594	.378	.239	.332	.289	.231	.0661	.103
N(HD /DE)										
A(HD)	182.	76.2	165.	92.0	63.2	109.	123.	72.0	27.8	27.2
1/T(HD)1	.0650	.0207	.0325	.0267	.0199	.0292	.0632	.0647	.0215	.0167
1/T(HD)2	-6.69	-3.83	-6.16	-5.22	-4.07	-5.93	-5.50	-6.18	-3.31	-4.97
1/T(HD)3	7.34	4.18	6.60	5.51	4.28	6.06	5.67	6.37	3.38	5.07
N(AZP/DE)										
A(AZP)	-29.6	-12.4	-71.1	-18.5	-13.3	-11.5	-28.7	7.01	-1.00	1.98
1/T(AZP)1	.0218	-.0105	.0107	.00983	.00613	.00918	.00782	.0117	.00350	-.0108
1/T(AZP)2	.0445	.0301	.0225	.0173	.0142	.0218	.0571	.0552	.0186	.0256
Z(AZP)1	(-18.5)	(-9.66)	(-9.84)	(12.2)	(-5.18)	(17.8)	(11.9)	.0142	(-17.9)	.00687
W(AZP)1	(19.0)	(9.95)	(10.1)	(-12.3)	(5.26)	(-19.4)	(-12.2)	22.0	(18.1)	18.4

TABLE VI-5

HL-10 LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS Off

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
STICK FIXED										
D(G)/D(U) (DEG/KT)	-.121	-.00405	-.0433	-.0134	.000279	-.0386	-.160	-.174	-.0448	-.0685
NZA (G/RAD)	11.5	4.11	12.9	6.94	4.54	7.72	8.14	7.58	2.39	4.76
DE/G (DEG/G)	3.03	9.36	2.70	4.14	5.26	4.80	5.81	8.92	43.5	18.7
CAP (RAD/SEC/SEC/G)	1.48	1.55	.791	.892	.731	1.36	1.63	2.21	3.21	1.48
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	--	--	--	--	--
1/C(1/10)	.516	.400	.510	.399	.343	.217	.206	.167	.0861	.114

TABLE VI-6

HL-10 LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.600	.950	1.10	1.20	1.50
YV	-.354	-.173	-.322	-.203	-.140	-.160	-.204	-.173	-.0564	-.0851
YB	-218.	-69.3	-232.	-125.	-88.2	-124.	-187.	-184.	-66.0	-124.
LB'	-102.	-43.1	-75.1	-49.5	-34.0	-71.4	-71.5	-69.7	-25.5	-34.5
NB'	13.9	5.51	13.1	7.79	5.53	12.4	14.0	11.0	3.96	4.91
LP'	-1.49	-.723	-1.13	-.686	-.473	-.710	-.627	-.524	-.175	-.201
NP'	.0390	.0189	.0240	.0179	.0115	.0119	.00882	.00877	.00344	.00774
LR'	1.16	.561	.820	.532	.357	.477	.397	.351	.124	.180
NR'	-.458	-.248	-.382	-.235	-.162	-.245	-.234	-.185	-.0616	-.0799
Y*DA	-.00523	-.0104	-.00679	-.00547	-.00428	-.00899	-.00900	-.00590	.000154	0.
L'DA	36.0	15.5	30.7	17.0	10.7	18.5	18.2	16.7	5.23	7.52
N'DA	3.39	1.96	3.73	2.11	1.19	2.43	2.76	1.83	.0603	-.392
Y*DR	.0865	.0473	.0553	.0372	.0251	.0280	.0233	.0202	.00677	.00777
L'DR	13.0	5.12	13.0	6.67	4.87	5.82	6.53	6.50	2.45	3.94
N'DR	-10.6	-3.81	-8.77	-5.12	-3.51	-4.65	-4.60	-4.87	-1.75	-2.18

TABLE VI-7

HL-10 AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
1/T(UE)1	.0868	.0796	.0509	.0548	.0440	.0434	.0367	.0375	.0249	.0201
1/T(UE)2	.812	.383	.683	.375	.265	.417	.389	.298	.171	.124
Z(DET)1	.132	.0777	.107	.0762	.0579	.0602	.0574	.0518	.0179	.0320
W(DET)1	5.64	4.39	5.17	4.55	4.02	5.44	5.57	5.27	2.73	3.46
NUMERATORS										
N(B /DA)										
A(B)	-.00523	-.0104	-.00679	-.00547	-.00428	-.00899	-.00900	-.00590	.000154	1.95
1/T(B)1	-578.	-307.	-291.	-457.	-539.	-243.	-193.	-394.	.0874	
Z(B)1	-.172	.546	-.415	.337	.587	.182	.0638	.318	(.153)	.973
W(B)1	.587	.358	.541	.313	.216	.315	.313	.201	(4339.)	.0726
N(P /DA)										
A(P)	36.0	15.5	30.7	17.0	10.7	18.5	18.2	16.7	5.23	7.52
1/T(P)1	.0218	-.00737	.0120	.00983	.00395	.00802	.00743	.0111	.00339	-.00987
Z(P)1	.103	.0817	.0862	.0695	.0591	.0537	.0535	.0481	.0282	.0473
W(P)1	4.83	3.23	4.69	3.67	2.98	4.60	4.92	4.26	2.05	1.75
N(R /DA)										
A(R)	3.39	1.96	3.73	2.11	1.19	2.43	2.76	1.83	.0603	-.392
1/T(R)1	.305	.247	.234	.192	.158	.167	.141	.115	.197	.0955
1/T(R)2	(.148)	(.0725)	(.120)	(.0750)	(.0519)	(.0586)	(.0556)	(.0484)	(.0240)	-3.50
1/T(R)3	(6.65)	(5.31)	(5.81)	(5.47)	(5.19)	(6.39)	(6.31)	(6.47)	(7.14)	3.54
N(PHI/DA)										
A(PHI)	34.6	15.7	29.7	16.6	0.6	18.1	17.6	16.0	5.22	7.33
Z(PHI)1	.102	.0807	.0853	.0702	.0598	.0541	.0538	.0491	.0291	.0415
W(PHI)1	4.74	3.26	4.64	3.62	2.95	4.54	4.87	4.13	2.03	1.86
N(AYP/DA)										
A(AYP)	69.5	30.3	62.3	34.1	20.0	34.8	35.1	29.0	7.89	7.98
1/T(AYP)1	-.293	.271	-.234	.286	.200	.198	.207	.178	.0838	.0620
1/T(AYP)2	.365	-.387	.506	-.320	-.498	-.216	-.228	-.332	-.617	.114
1/T(AYP)3	(.123)	(.126)	(.0933)	(.111)	(.167)	(.0679)	(.0687)	(.0963)	(.283)	4.71
1/T(AYP)4	(4.49)	(3.10)	(4.33)	(3.22)	(2.24)	(4.54)	(4.62)	(3.34)	(1.19)	-4.73

TABLE VI-8

HL-10 RUDDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
1/T(DET)1	.0868	.0796	.0509	.0548	.0440	.0434	.0367	.0375	.0249	.0201
1/T(DET)2	.812	.383	.683	.375	.265	.417	.389	.298	.171	.124
ζ(DET)1	.132	.0777	.107	.0762	.0579	.0602	.0574	.0518	.0179	.0320
W(DET)1	5.64	4.39	5.17	4.55	4.02	5.44	5.57	5.27	2.73	3.46
NUMERATORS										
N(B /DR)										
A(B)	.0865	.0473	.0553	.0372	.0251	.0280	.0233	.0202	.00677	.00777
1/T(B)1	.00111	-.0316	.00183	-.00794	-.0105	-.00222	.00348	.00498	-.00203	-.0116
1/T(B)2	1.17	.527	.881	.506	.343	.544	.480	.396	.175	.161
1/T(B)3	148.	112.	200.	181.	195.	213.	261.	313.	306.	380.
N(P /DR)										
A(P)	13.0	5.12	13.0	6.67	4.87	5.82	6.53	6.50	2.45	3.94
1/T(P)1	.0219	-.00739	.0120	.00985	.00395	.00802	.00743	.0111	.00339	-.00989
1/T(P)2	7.91	4.83	6.01	5.27	4.17	6.42	5.90	6.26	3.73	-3.72
1/T(P)3	-8.66	-5.22	-6.19	-5.53	-4.30	-6.75	-6.00	-6.39	-3.78	3.73
N(R /DR)										
A(R)	-10.6	-3.81	-8.77	-5.12	-3.51	-4.65	-4.60	-4.87	-1.75	-2.18
1/T(R)1	.306	.247	.234	.192	.159	.167	.141	.115	.196	.0955
ζ(R)1	.183	.0816	.172	.0952	.0685	.0830	.0855	.0713	.00461	.0345
W(R)1	3.88	3.40	3.20	3.24	2.91	3.70	3.55	2.67	1.67	2.31
N(PHI/DR)										
A(PHI)	17.3	4.79	15.4	7.61	5.13	6.71	7.50	8.34	2.67	2.88
1/T(PHI)1	6.86	5.04	-5.42	4.86	4.03	5.90	-5.40	-5.28	3.56	4.53
1/T(PHI)2	-6.98	-5.52	5.48	-4.98	-4.12	-6.07	5.41	5.33	-3.58	-4.63
N(AYP/DR)										
A(AYP)	-3.07	1.32	.978	-.991	-.182	-.445	.609	-1.02	-.0183	2.69
1/T(AYP)1	-.0430	-.123	-.0195	-.0404	-.0393	-.0557	-.0218	-.0131	-.0143	-.0207
1/T(AYP)2	.681	.300	.613	.330	.235	.260	.297	.248	.132	.129
1/T(AYP)3	(.170)	17.2	43.8	(.125)	(.187)	(.139)	39.9	(.0789)	(.196)	11.8
1/T(AYP)4	(33.9)	-20.6	-63.9	(31.5)	(51.9)	(42.9)	-48.1	(36.5)	(92.8)	-12.1

TABLE VI-9

HL-10 AILERON TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
1/T(DET)1	.00751	.00201	.00626	.00491	.00328	.00533	.00555	.00620	.00269	-.000773
1/T(DET)2	.323	.275	.269	.224	.187	.214	.197	.156	.232	.120
1/T(DET)3	2.55	14.8	2.10	19.9	13.6	17.7	17.0	18.7	6.75	8.54
Z(DET)1	(7.48)	.638	(7.01)	.709	.533	.673	.706	.608	.439	.445
W(DET)1	(42.0)	3.75	(34.0)	3.63	3.22	4.37	4.40	4.22	1.91	2.53
NUMERATORS										
N(B /DA)										
A(B)	-.00523	-.0104	-.00679	-.00547	-.00428	-.00899	-.00900	-.00590	.000154	1.93
1/T(B)1	.00374	.00600	.00352	.00391	.00399	.00442	.00408	.00295	.00277	.00272
1/T(B)2	.304	.245	.232	.190	.157	.164	.138	.113	.196	.0951
1/T(B)3	69.8	25.1	76.0	37.5	23.0	37.7	44.7	35.9	8.10	6.75
1/T(B)4	-830.	-352.	-453.	-531.	-576.	-292.	-248.	-435.	4345.	
N(P /DA)										
A(P)	36.0	15.5	30.7	17.0	10.7	18.5	18.2	16.7	5.23	7.52
1/T(P)1	.0225	-.00735	.0122	.00989	.00395	.00803	.00744	.0111	.00339	-.00981
1/T(P)2	48.0	18.0	41.8	23.9	16.3	21.4	.561	22.1	6.93	7.93
Z(P)1	.886	.755	.880	.790	.742	.914	(.645)	.891	.693	.640
W(P)1	.394	.438	.414	.430	.424	.570	(22.0)	.519	.447	.357
N(R /DA)										
A(R)	3.39	1.96	3.73	2.11	1.19	2.43	2.76	1.63	.0603	-.392
1/T(R)1	.305	.247	.234	.192	.158	.167	.141	.115	.197	.0955
1/T(R)2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
1/T(R)3	(.148)	(.0725)	(.120)	(.0750)	(.0519)	(.0586)	(.0556)	(.0484)	(.0240)	-3.50
1/T(R)4	(6.65)	(5.31)	(5.81)	(5.47)	(5.19)	(6.39)	(6.31)	(6.47)	(7.14)	3.54

TABLE VI-9 Continued

d(PHI/DA)										
A(PHI)	34.6	15.7	29.7	16.6	10.6	18.1	17.6	16.0	5.22	7.33
1/T(PHI)1	49.9	17.8	43.2	24.5	16.4	22.0	22.8	23.2	6.95	8.09
Z(PHI)1	.889	.757	.879	.786	.739	.901	.985	.067	.691	.651
W(PHI)1	.396	.443	.406	.420	.419	.556	.585	.493	.443	.375
d(AYP/DA)										
A(AYP)	69.5	30.3	62.3	34.1	20.0	34.8	35.1	29.0	7.89	7.98
1/T(AYP)1	.00683	.0147	.00883	.00662	.00649	.0116	.00774	.00468	.00393	.00318
1/T(AYP)2	.304	.246	.232	.190	.157	.165	.138	.114	.200	.0957
1/T(AYP)3	-3.16	-2.01	-3.47	-2.97	-2.90	-2.22	-3.24	-3.90	-1.84	4.25
1/T(AYP)4	4.19	3.00	4.68	4.20	4.17	3.90	5.65	5.84	2.56	-4.58
1/T(AYP)5	42.3	15.3	35.3	19.8	13.3	17.6	17.0	18.0	6.54	8.91

TABLE VI-10

HL-10 RUDDER TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
1/T(DET)1	.00751	.00201	.00626	.00491	.00328	.00533	.00555	.00620	.00269	-.000773
1/T(DET)2	.323	.275	.269	.224	.187	.214	.197	.156	.232	.120
1/T(DET)3	2.55	14.8	2.10	19.9	13.6	17.7	17.0	18.7	6.75	8.54
Z(DET)1	(7.48)	.638	(7.01)	.709	.533	.673	.706	.608	.439	.445
W(DET)1	(42.0)	3.75	(34.0)	3.63	3.22	4.37	4.40	4.22	1.91	2.53
NUMERATORS										
N(B /DR)										
A(B)	.0865	.0473	.0553	.0372	.0251	.0280	.0233	.0202	.00677	.00777
1/T(B)1	.0183	-.0117	.0107	.00724	.00150	.00658	.00693	.0103	.00251	-.0102
1/T(B)2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
1/T(B)3	7.68	2.96	6.52	3.37	2.00	3.60	3.72	3.24	1.06	1.14
1/T(B)4	149.	113.	200.	182.	196.	214.	262.	314.	306.	380.
N(P /DR)										
A(P)	13.0	5.12	13.0	6.47	4.87	5.82	6.53	6.50	2.45	3.94
1/T(P)1	.0219	-.00739	.0120	.00985	.00395	.00802	.00743	.0111	.00339	-.00989
1/T(P)2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
1/T(P)3	7.91	4.83	5.01	5.27	4.17	6.42	5.90	6.26	3.73	-3.72
1/T(P)4	-8.66	-5.22	-6.19	-5.53	-4.30	-6.75	-6.00	-6.39	-3.78	3.73
N(R /DR)										
A(R)	-10.6	-3.81	-8.77	-5.12	-3.51	-4.65	-4.60	-4.87	-1.75	-2.18
1/T(R)1	.321	.263	.238	.198	.162	.173	.142	.115	.210	.0961
1/T(R)2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
Z(R)1	(1.90)	.631	(1.47)	.713	.497	.677	.710	.592	.330	.330
W(R)1	(7.53)	3.30	(6.88)	3.20	2.80	3.64	3.54	3.68	1.01	2.30

TABLE VI-10 Continued

N(PHI/DR)										
A(PHI)	17.3	4.79	15.4	7.61	5.13	6.71	7.50	8.34	2.67	2.88
1/T(PHI)1	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
1/T(PHI)2	-6.02	4.92	-4.86	-4.73	-4.06	-5.79	-5.11	-4.86	-3.54	4.30
1/T(PHI)3	7.87	-5.65	6.06	5.11	4.09	6.18	5.70	5.76	3.60	-4.90
V(AYP/DR)										
A(AYP)	-3.07	1.32	.978	-.991	-.102	-.445	.609	-1.02	-.0183	2.69
1/T(AYP)1	.0104	-.0400	.00743	.00105	-.00468	.00313	.00350	.00814	-.822E-4	-.0115
1/T(AYP)2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
1/T(AYP)3	6.2[illegible]	1.20	-193.	2.08	1.23	1.61	2.41	2.11	.672	.937
1/T(AYP)4	11.1	9.30	(.954)	(.935)	24.6	20.4	17.3	(.630)	40.7	10.9
1/T(AYP)5	61.0	-34.1	(7.71)	(29.6)	103.	84.9	-99.3	(35.2)	208.	[illegible]

TABLE VI-11

HL-10 LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	05 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DR PERIOD (SEC)	1.12	1.44	1.22	1.38	1.56	1.16	1.13	1.19	2.30	1.82
1/C(1/2)	1.20	.706	.974	.693	.526	.547	.521	.470	.162	.290
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--	--	--
P(1)	25.8	11.1	31.2	21.5	9.65	--	--	--	7.43	2.44
P(2)	25.8	11.0	31.1	21.5	9.65	--	--	--	7.27	.860
P(3)	26.3	13.7	--	--	13.0	--	--	--	10.2	4.95
P(2)/P(1)	.000	.988	.997	.998	.000	--	--	--	.979	.353
P(OSC)/P(AV)	.00471	.0619	--	--	.0800	--	--	--	.0967	.622
W(PHI)/W(D)	.842	.743	.898	.795	.733	.836	.873	.784	.744	.5 7
DEL-B-MAX	.120	.290	.115	.201	.257	.123	.0928	.146	.179	.309
PHI TO BETA, PHASE	1.21	1.54	1.53	.799	.873	1.29	.497	.153	-358.	.202
PHI TO BETA	3.38	2.21	2.94	2.48	4.12	2.49	2.40	2.66	3.48	2.68
PHI TO VE	.368	.406	.352	.373	.389	.353	.339	.374	.743	.455

HL-10 DATA SOURCES

1. Ladson, Charles L., and Acquilla S. Hill, Aerodynamics of a Model of the HL-10 Flight Test Vehicle at Mach 0.35 to 1.80, NASA TN D-6018, Feb. 1971

2. Pyle, Jon S., Lift and Drag Characteristics of the HL-10 Lifting Body during Subsonic Gliding Flight, NASA TN D-6263, Mar. 1971

3. Ware, George M., Full Scale Wind Tunnel Investigation of the Aerodynamic Characteristics of the HL-10 Manned Lifting Entry Vehicle, NASA TMX-1160, Oct. 1965.

SECTION VII

LOCKHEED JETSTAR

JETSTAR BACKGROUND

The Jetstar is a four engine utility transport. Controls consist of conventional ailerons, elevators, and rudder. Ailerons and elevators are mechanically actuated with hydraulic boost. The rudder is mechanically activated but assisted by a servo tab.

The primary source of aerodynamic data was NASA CR-544. Power approach aerodynamics were estimated using CR-544 and flight test data from FTC-TDR-62-24C-140. The control system description was based solely on flight test data from the latter reference.

JETSTAR

Nominal Configuration

Slipper Tanks Installed
Heavy Gross Weight
$W = 38204$ lb
c.g. at $0.25\ \bar{c}$, W.L. 94.2
$I_x = 118773$ slug-ft^2
$I_y = 135869$ slug-ft^2
$I_z = 243504$ slug-ft^2
$I_{xz} = 5061$ slug-ft^2

Power Approach Configuration

Slipper Tanks Installed
Light Gross Weight
Gear Down
40% Flaps
$1.4\ V_s$
$W = 23904$ lb
c.g. at $0.25\ \bar{c}$, W.L. 94.2
$I_x = 42273$ slug-ft^2
$I_y = 126099$ slug-ft^2
$I_z = 160104$ slug-ft^2
$I_{xz} = 5470$ slug-ft^2

Flight Envelope

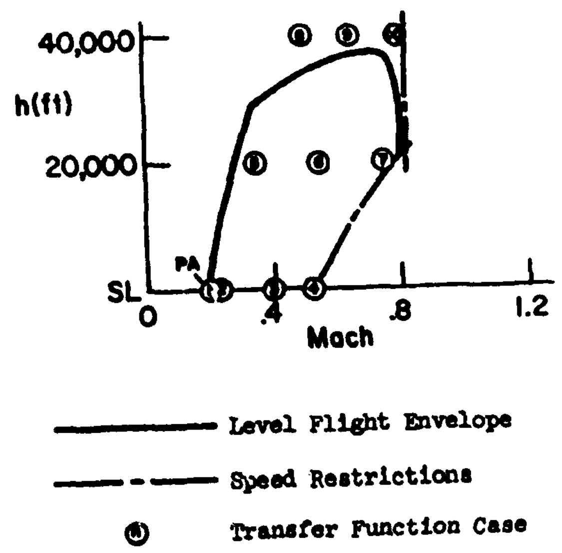


Figure VII-1. Jetstar Flight Conditions

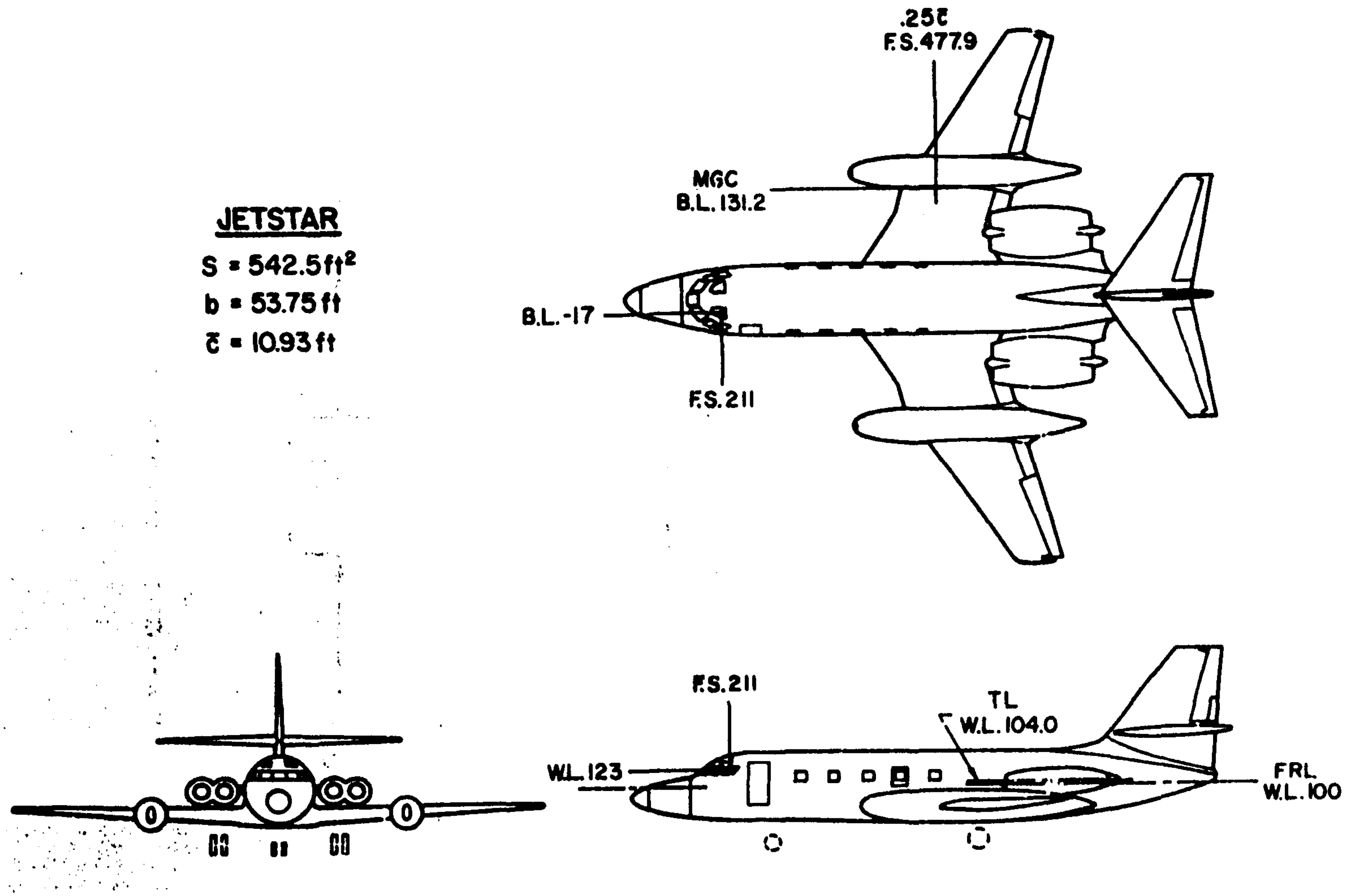


Figure VII-2. Jetstar General Arrangement

JETSTAR

PITCH AXIS

$$F_{ST}(\mathrm{lb}) \longrightarrow \boxed{\frac{1}{52 + 2.95\bar{q}}} \longrightarrow \delta_e(\mathrm{rad})$$

Note: Angle of attack effects on elevator hinge moment are neglected

ROLL AXIS

$$F_{ST}^{LAT}(\mathrm{lb}) \longrightarrow \boxed{\frac{1}{.75\bar{q}}} \longrightarrow \delta_a(\mathrm{rad})$$

YAW AXIS

$$F_{PED}(\mathrm{lb}) \longrightarrow \boxed{\frac{1}{9.7\bar{q}}} \longrightarrow \delta_r(\mathrm{rad})$$

Figure VII-3. Jetstar Control System

TABLE VII-1

JETSTAR

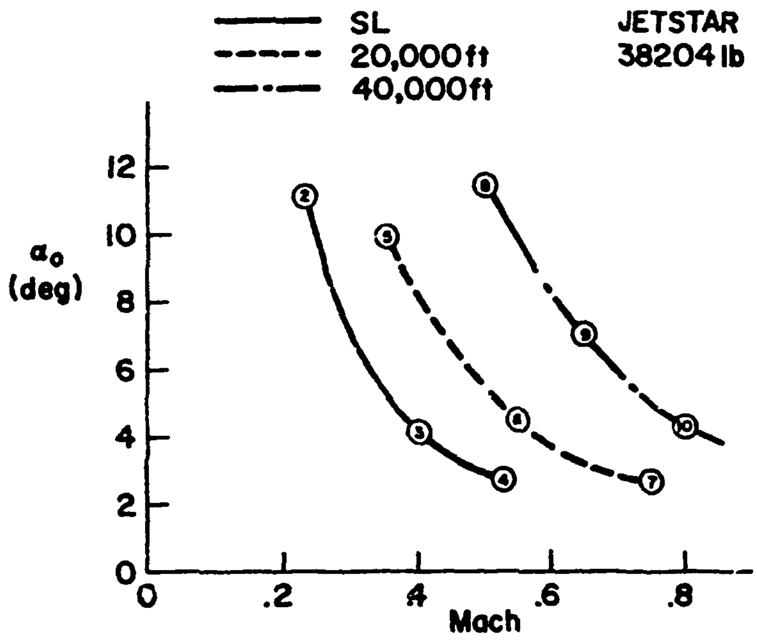
Power Approach Non-Dimensional Stability Derivatives

h = sea level

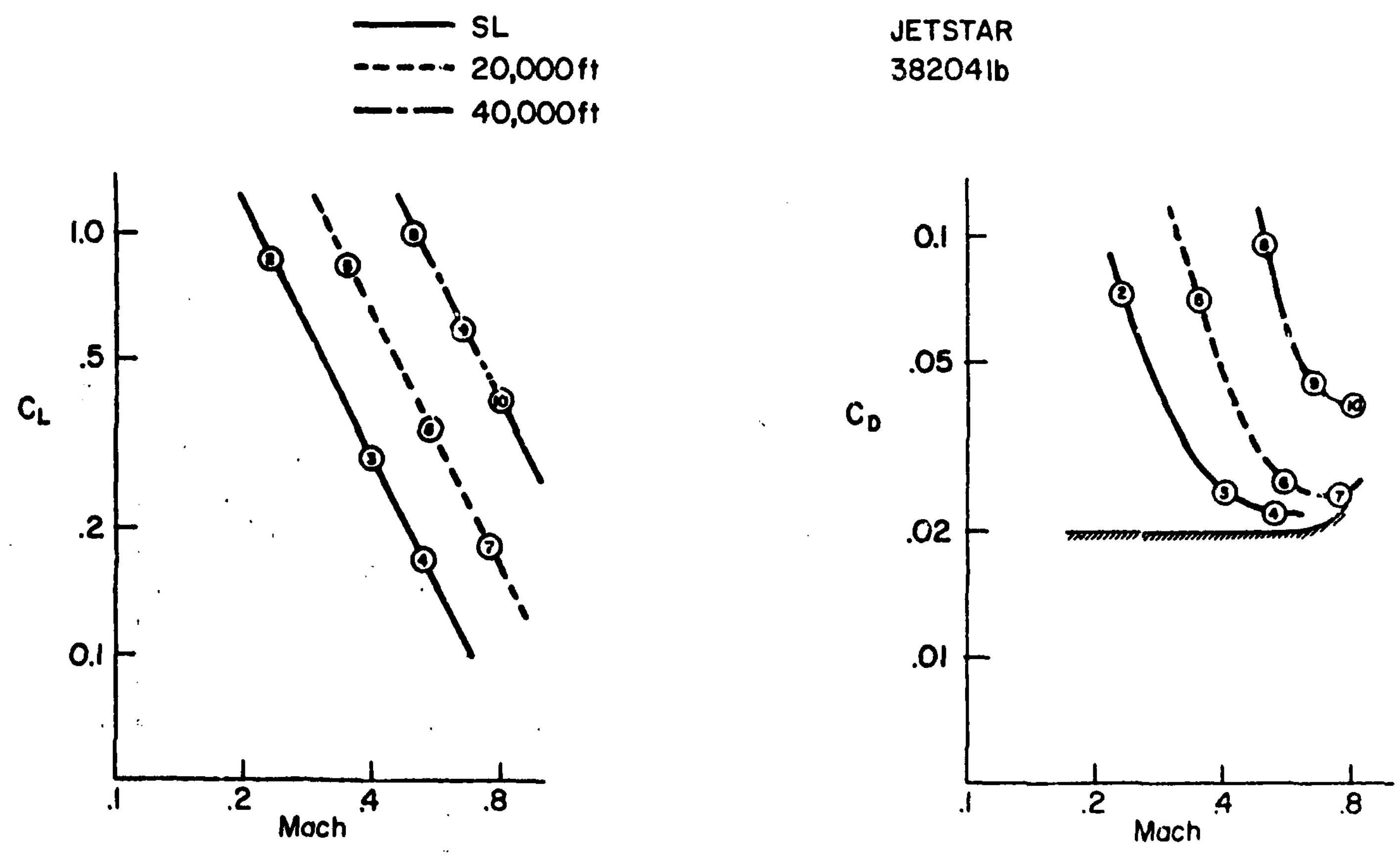
V_{T_0} = 224 ft/sec = 132.5 kt

α_0 = 6.5°

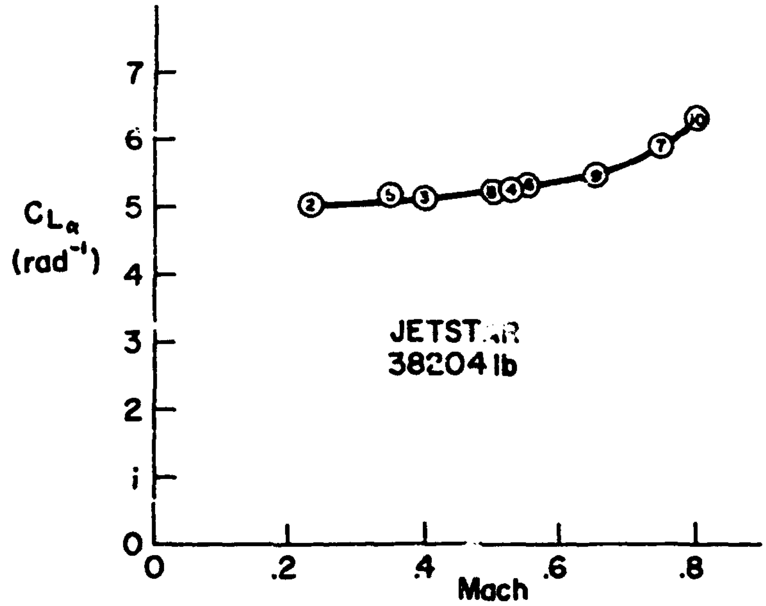
Longitudinal	Lateral-Directional (Body Axis)
C_L = .737	C_{y_β} = −.72/rad
C_D = .095	C_{n_β} = .137/rad
C_{L_α} = 5.0/rad	C_{ℓ_β} = −.103/rad
C_{D_α} = .75/rad	C_{ℓ_p} = −.37/rad
C_{m_α} = −.80/rad	C_{n_p} = −.14/rad
$C_{m_{\dot\alpha}}$ = −3.0/rad	C_{ℓ_r} = .11/rad
C_{m_q} = −8.0/rad	C_{n_r} = −.16/rad
$C_{L_{\delta_e}}$ = .4/rad	$C_{n_{\delta_a}}$ = −.0075/rad
$C_{m_{\delta_e}}$ = −.81/rad	$C_{\ell_{\delta_a}}$ = .054/rad
	$C_{y_{\delta_r}}$ = .175/rad
	$C_{n_{\delta_r}}$ = −.063/rad
	$C_{\ell_{\delta_r}}$ = .029/rad

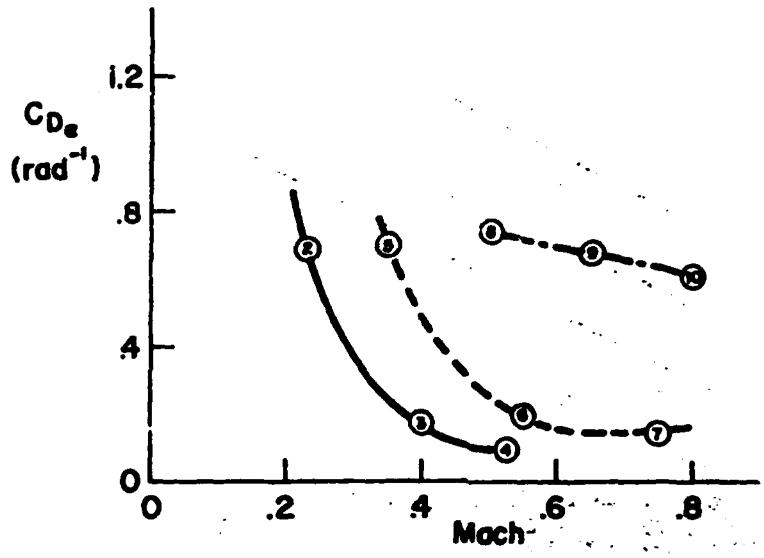


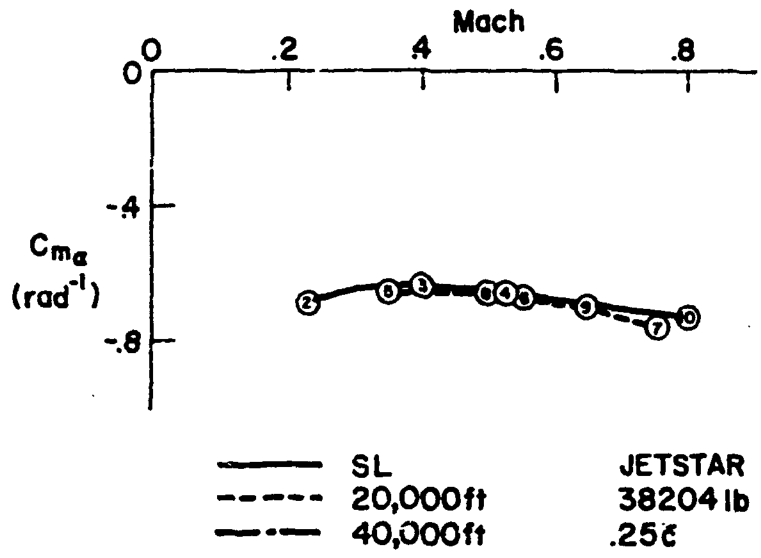
SL
20,000 ft
40,000 ft
JETSTAR
38204 lb
α_o (deg)
Mach



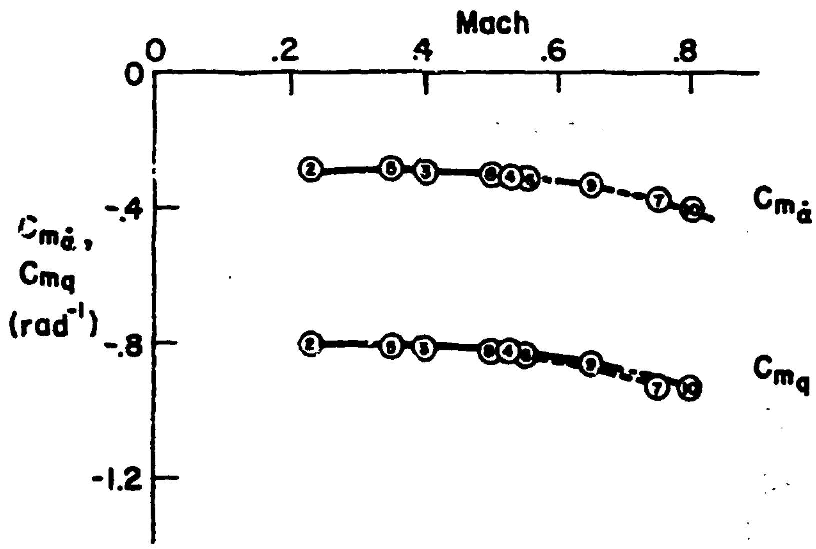
SL
20,000ft
40,000ft
JETSTAR
38204lb
C_L
1.0
.5
.2
0.1
.1
.2
.4
.8
Mach
C_D
0.1
.05
.02
.01
.1
.2
.4
.8
Mach


JETSTAR
38204 lb
C_{L_α}
(rad⁻¹)
Mach

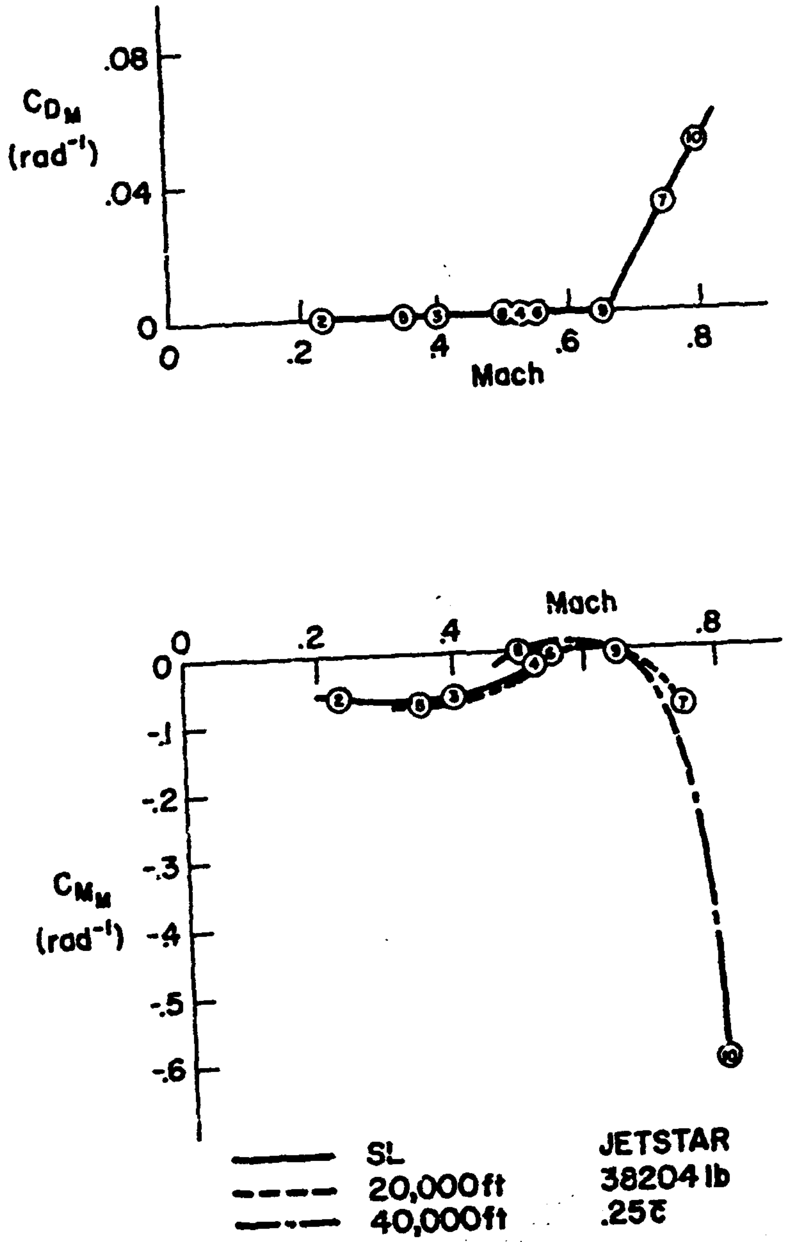

C_{D_α}
(rad⁻¹)
Mach



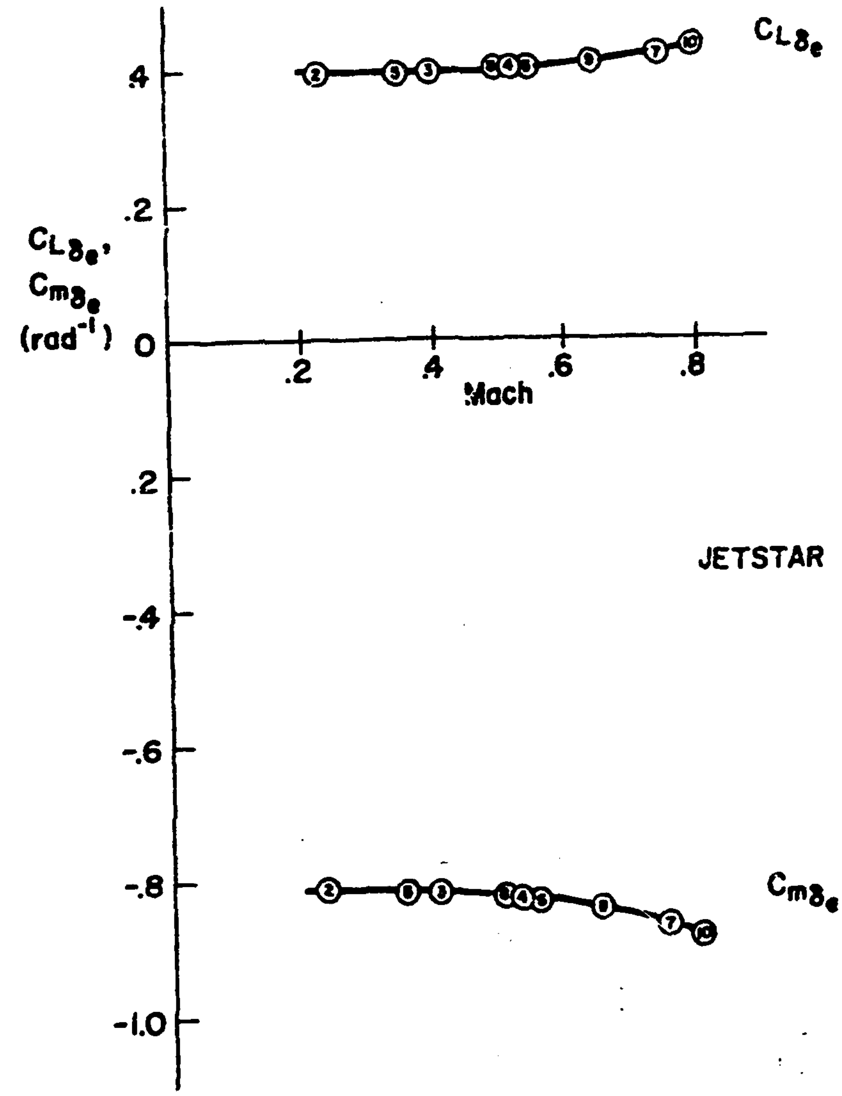
Mach
0
.2
.4
.6
.8
0
-.4
-.8
C_{m_α}
(rad^{-1})
SL
20,000ft
40,000ft
JETSTAR
38204 lb
.25$\bar{c}$

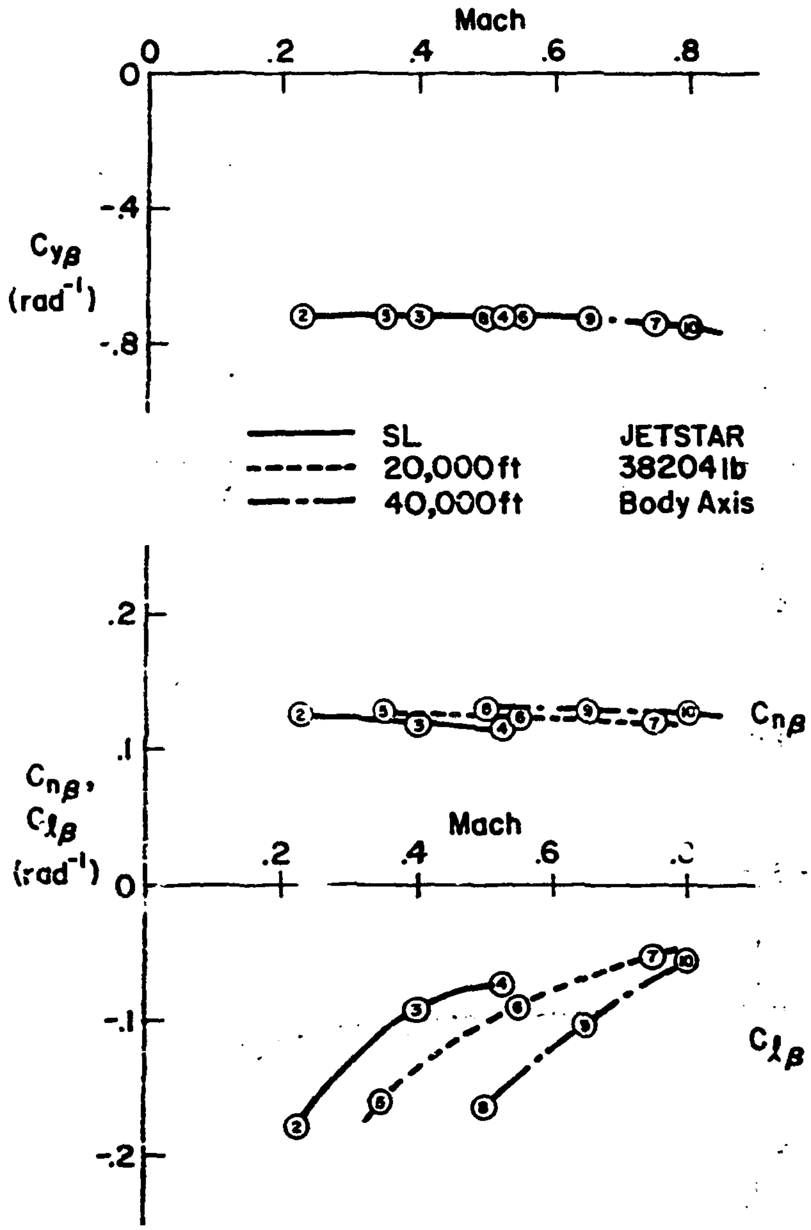


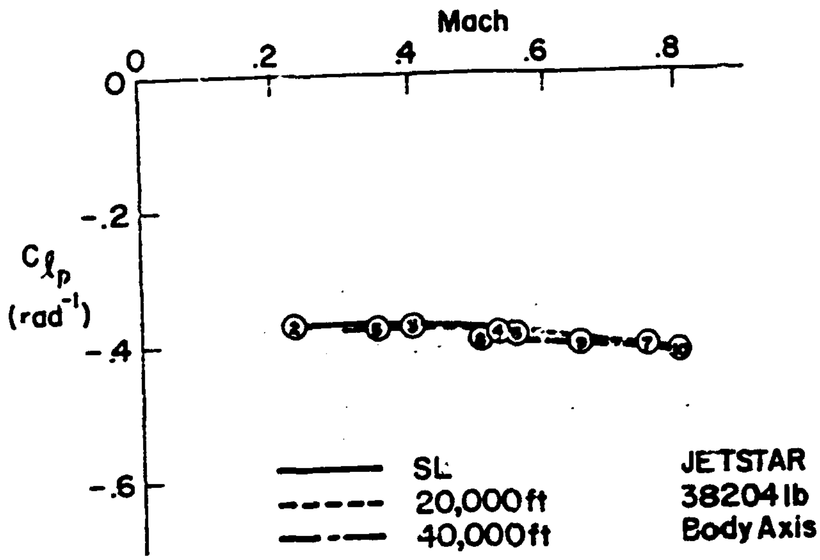
Mach
0
.2
.4
.6
.8
0
-.4
-.8
-1.2
$C_{m_{\dot\alpha}}$,
C_{m_q}
(rad^{-1})
$C_{m_{\dot\alpha}}$
C_{m_q}

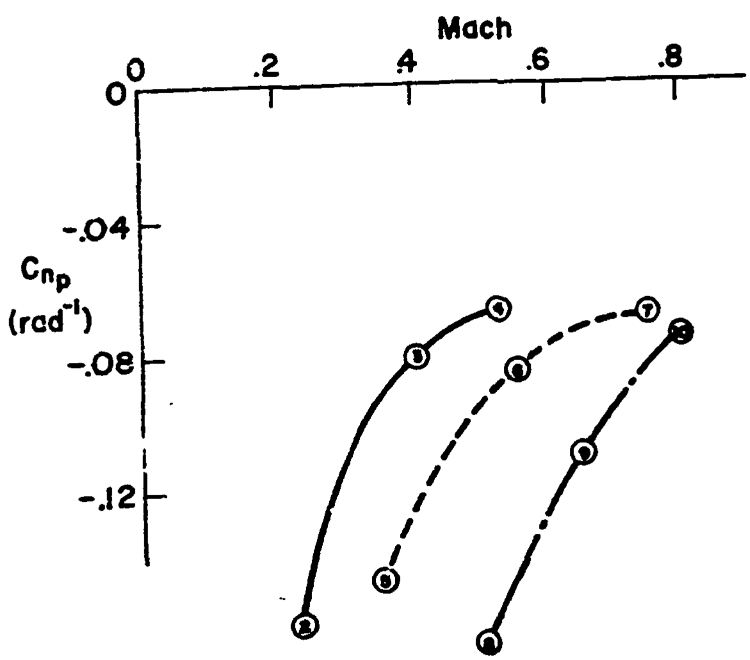


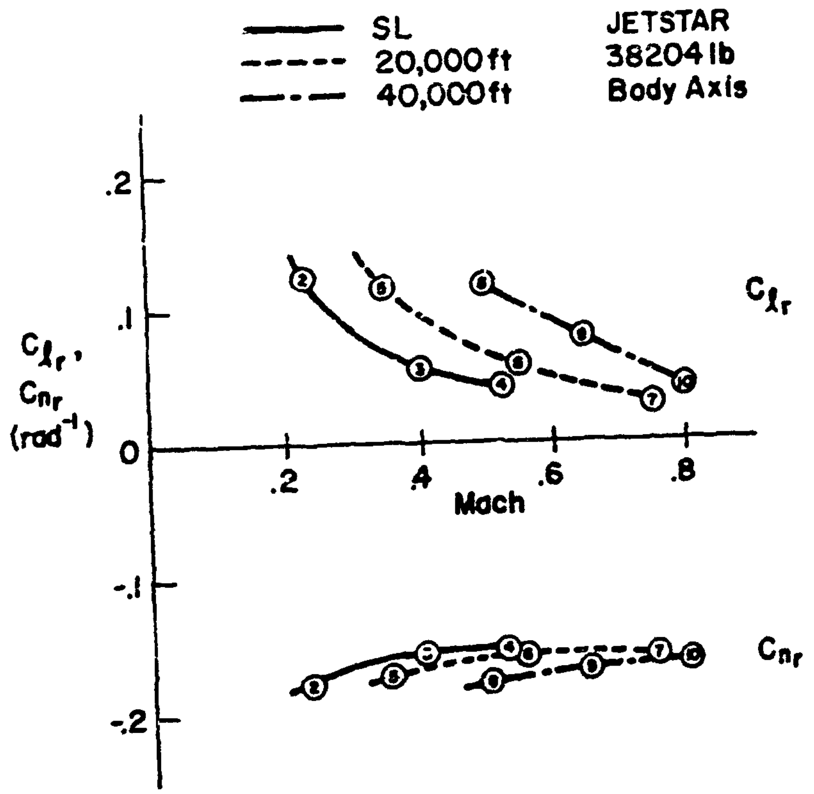
C_{D_M}
(rad^{-1})
.08
.04
0
0
.2
.4
.6
.8
Mach
Mach
0
.2
.4
.8
0
-.1
-.2
-.3
-.4
-.5
-.6
C_{M_M}
(rad^{-1})
SL
20,000ft
40,000ft
JETSTAR
38204 lb
.25c̄

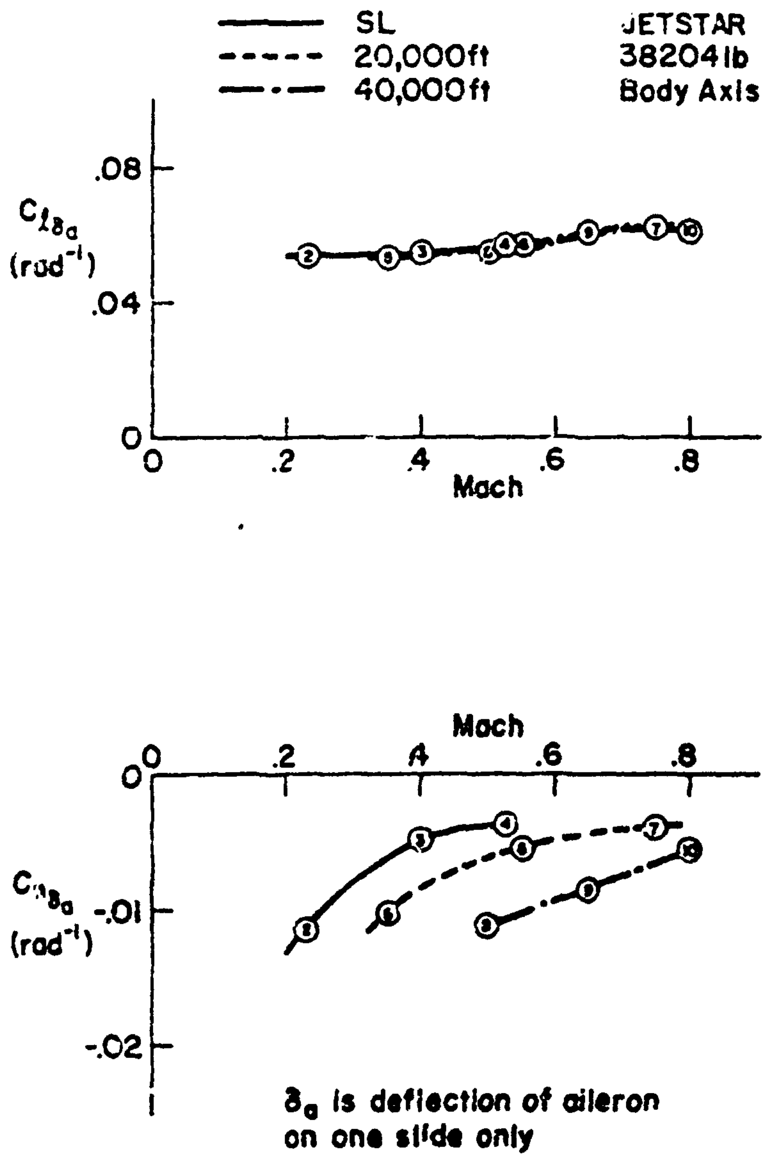

$C_{L_{\delta_e}}$
$C_{L_{\delta_e}}$, $C_{m_{\delta_e}}$ (rad^{-1})
.4
.2
0
.2
-.4
-.6
-.8
-1.0
.2
.4
.6
.8
Mach
JETSTAR
$C_{m_{\delta_e}}$


Mach
0
.2
.4
.6
.8
0
-.4
C_{y_β} (rad^{-1})
-.8
SL
20,000 ft
40,000 ft
JETSTAR
38204 lb
Body Axis
.2
.1
C_{n_β}, C_{l_β} (rad^{-1})
0
-.1
-.2
C_{n_β}
C_{l_β}

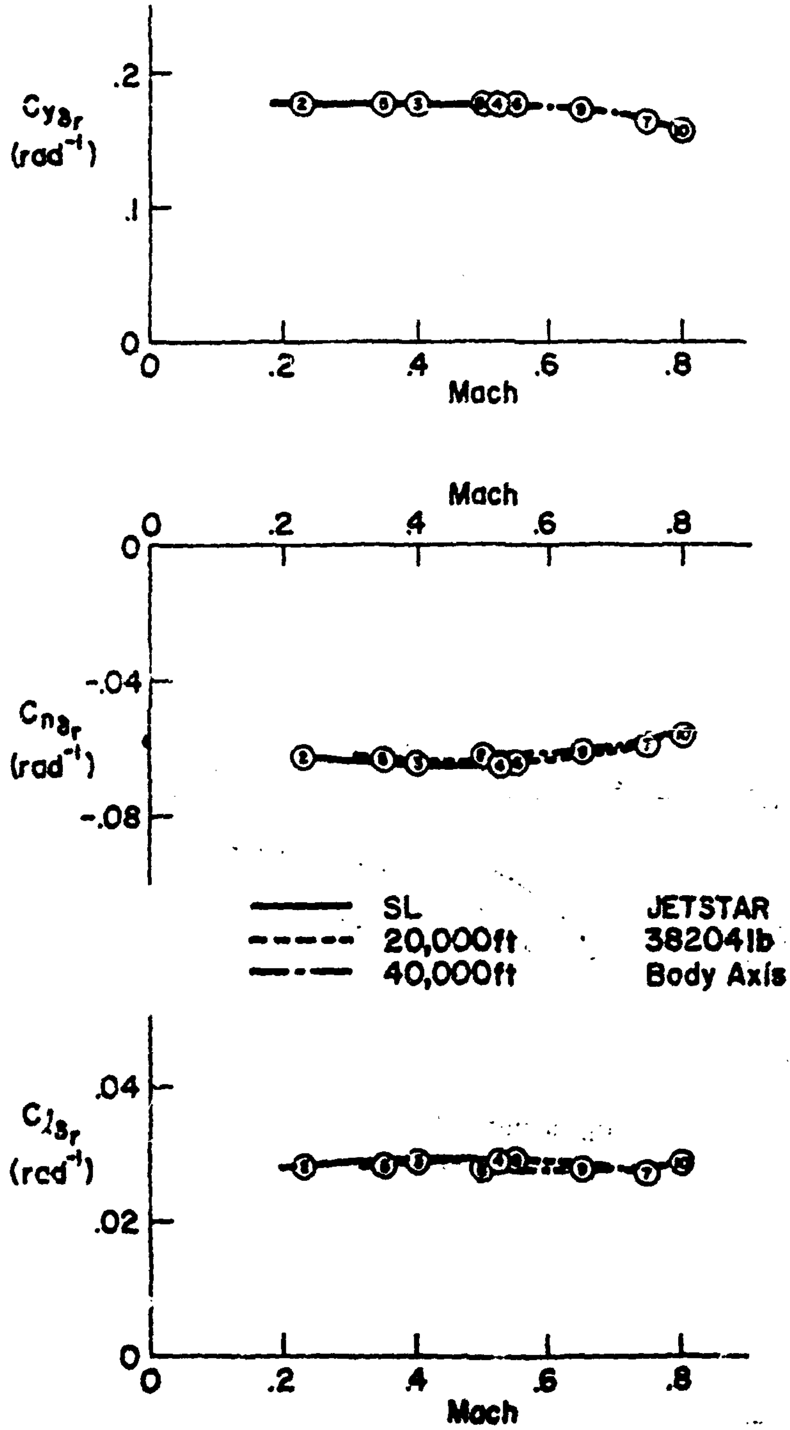

Mach
0
.2
.4
.6
.8
0
-.2
C_{l_p}
(rad^{-1})
-.4
-.6
SL
20,000 ft
40,000 ft
JETSTAR
38204 lb
Body Axis


Mach
0
.2
.4
.6
.8
0
-.04
C_{n_p}
(rad^{-1})
-.08
-.12


SL
20,000 ft
40,000 ft
JETSTAR
38204 lb
Body Axis
C_{l_r}, C_{n_r} (rad^{-1})
.2
.1
0
-.1
-.2
.2
.4
.6
.8
Mach
C_{l_r}
C_{n_r}



SL
20,000ft
40,000ft
JETSTAR
38204lb
Body Axis
$C_{l_{\delta_a}}$ (rad^{-1})
.08
.04
0
Mach
0
.2
.4
.6
.8
$C_{n_{\delta_a}}$ (rad^{-1})
-.01
-.02
δ_a is deflection of aileron on one side only



.2
$C_{y_{\delta_r}}$ (rad^{-1})
.1
0
0
.2
.4
.6
.8
Mach
Mach
0
.2
.4
.6
.8
0
-.04
$C_{n_{\delta_r}}$ (rad^{-1})
-.08
SL
20,000ft
40,000ft
JETSTAR
38204lb
Body Axis
.04
$C_{l_{\delta_r}}$ (rad^{-1})
.02
0
0
.2
.4
.6
.8
Mach

TABLE VII-2

JETSTAR DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M(-)	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
VTO(FPS)	224.	257.	447.	586.	363.	570.	778.	484.	629.	774.
VTO(KTAS)	133.	152.	265.	347.	215.	338.	461.	287.	373.	459.
VTO(KCAS)	132.	152.	265.	347.	158.	252.	348.	146.	193.	243.
W(LBS)	23905.	38205.	38205.	38205.	38205.	38205.	38205.	38205.	38205.	38205.
C.G.(MGC)	.250	.250	.250	.250	.250	.250	.250	.250	.250	.250
IX (SLUG-FT SQ)	42275.	118779.	118779.	118779.	118779.	118779.	118779.	118779.	118779.	118779.
IY (SLUG-FT SQ)	126106.	135876.	135876.	135876.	135876.	135876.	135876.	135876.	135876.	135876.
IZ (SLUG-FT SQ)	160113.	243518.	243518.	243518.	243518.	243518.	243518.	243518.	243518.	243518.
IXZ(SLUG-FT SQ)	5470.	5061.	5061.	5061.	5061.	5061.	5061.	5061.	5061.	5061.
EPSILON(DEG)	-2.45	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32
Q(PSF)	59.4	78.4	237.	408.	83.5	206.	383.	69.0	117.	177.
QC(PSF)	60.0	79.4	247.	437.	86.0	222.	440.	73.4	129.	207.
ALPHA(DEG)	6.50	11.2	4.00	2.70	9.90	4.50	2.60	11.4	7.00	4.20
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
LZP(FT)	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40
ITH(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LTH(FT)	-.820	-.820	-.820	-.820	-.820	-.820	-.820	-.820	-.820	-.820

TABLE VII-3

JETSTAR LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
XU *	-.0166	-.00456	-.0102	-.0136	-.00324	-.00697	-.0157	-.00353	-.00168	-.211E-5
ZU *	-.175	-.103	-.0593	-.0335	-.0804	-.0436	-.0212	-.0614	-.0408	-.0348
MU *	.00131	.00175	.000549	.000727	.00102	.000815	-.000479	.000902	.000747	-.00425
XW	.108	.164	.118	.103	.111	.0918	.0689	.0858	.0498	.0266
ZW	-1.01	-.723	-1.24	-1.65	-.565	-.881	-1.33	-.354	-.475	-.655
MW	-.00991	-.00902	-.0146	-.0201	-.00665	-.0107	-.0154	-.00401	-.00561	-.00760
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-.000910	-.000834	-.000848	-.000906	-.000447	-.000482	-.000574	-.000207	-.000237	-.000280
MQ	[illegible]	-.582	-1.03	-1.33	-.439	-.724	-1.09	-.279	-.380	-.506
XDE	1.97	2.78	3.02	3.51	2.62	2.96	3.36	2.49	2.66	2.54
ZDE	-17.2	-14.0	-43.2	-74.3	-15.0	-37.5	-73.5	-12.4	-21.7	-34.6
MDE	-2.26	-2.80	-8.38	-14.6	-2.95	-7.47	-14.5	-2.47	-4.27	-6.78
XDTH	.00135	.000842	.000842	.000842	.000842	.000842	.000842	.000842	.000842	.000842
ZDTH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MDTH	-.650E-5	-.604E-5	-.604E-5	-.604E-5	-.604E-5	-.604E-5	-.604E-5	-.604E-5	-.604E-5	-.604E-5

TABLE VII-4

JETSTAR ELEVATOR TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
DENOMINATOR										
1/T(DET)1	(.0521)	(.0293)	(.0626)	(.102)	(.0386)	(.0498)	-.0195	(.0600)	(.0492)	.102
1/T(DET)2	(.188)	(.160)	(.0797)	(.0644)	(.115)	(.0751)	.0339	(.0937)	(.0709)	-.134
Z(DET)1	.528	.450	.475	.477	.355	.362	.382	.252	.259	.289
W(DET)1	1.66	1.66	2.79	3.75	1.64	2.60	3.77	1.44	1.93	2.45
NUMERATORS										
N(U /DE)										
A(U)	1.97	2.78	3.02	3.51	2.62	2.96	3.34	2.49	2.66	2.54
1/T(U)1	28.5	50.2	86.4	115.	70.1	113.	154.	94.7	123.	151.
Z(U)1	.590	.384	.258	.252	.410	.274	.335	.378	.558	.727
W(U)1	1.11	.670	1.10	1.35	.529	.773	1.07	.340	.434	.596
N(W /DE)										
A(W)	-17.2	-14.0	-43.2	-74.5	-15.0	-37.5	-73.5	-12.4	-21.7	-34.6
1/T(W)1	29.7	50.9	87.4	116.	70.7	114.	155.	95.1	124.	152.
Z(W)1	.0612	.00143	.0704	.146	.0105	.0581	.270	.0191	.00430	-.0104
W(W)1	.161	.118	.0662	.0427	.0867	.0515	.0273	.0659	.0476	.0232
N(THE/DE)										
A(THE)	-2.25	-2.79	-8.34	-14.5	-2.94	-7.45	-14.5	-2.47	-4.27	-6.77
1/T(THE)1	.0340	.0297	.0160	.0155	.0199	.0118	.0159	.0198	.00589	.00210
1/T(THE)2	.919	.653	1.17	1.57	.515	.824	1.25	.317	.443	.626
N(HD /DE)										
A(HD)	17.4	14.3	43.3	74.6	15.3	37.7	73.5	12.6	21.8	34.7
1/T(HD)1	-.00931	-.0168	.00715	.0118	-.0104	.00405	.0143	-.00751	-.00553	-.00182
1/T(HD)2	-4.77	-5.36	-9.36	-12.5	-5.73	-9.17	-13.1	-5.34	-7.10	-9.36
1/T(HD)3	5.57	6.19	10.8	14.4	6.36	10.2	14.7	5.74	7.64	10.1
N(AZP/DE)										
A(AZP)	32.7	47.9	142.	248.	50.3	128.	244.	42.4	73.1	116.
1/T(AZP)1	.0198	.0196	-.00611	-.00277	.0129	-.00549	-.00195	.0126	.00390	.00177
1/T(AZP)2	-.0297	-.0372	.0132	.0145	-.0237	.00951	.0162	-.0207	-.00952	-.00361
Z(AZP)1	.140	.106	.0999	.100	.0790	.0746	.0777	.0550	.0533	.0565
W(AZP)1	3.76	3.11	5.54	7.33	3.29	5.23	7.54	2.98	4.02	5.32

TABLE VII-5

JETSTAR THRUST TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5
H	SL	SL	SL	SL	20 K
M	.200	.230	.400	.525	.350
DENOMINATOR					
1/T(DET)1	(.0521)	(.0293)	(.0626)	(.102)	(.0386)
1/T(DET)2	(.188)	(.160)	(.0797)	(.0644)	(.115)
Z(DET)1	.528	.456	.475	.477	.355
W(DET)1	1.66	1.66	2.79	3.75	1.64
NUMERATORS					
N(U /DTH)					
A(U)	.00135	.000842	.000842	.000842	.000842
1/T(U)1	.0430	.0409	.0327	.0251	.0348
Z(U)1	.546	.547	.508	.495	.474
W(U)1	1.68	1.67	2.80	3.75	1.66
N(W /DTH)					
A(W)	-.00165	-.00157	-.00272	-.00354	-.00220
1/T(W)1	(-.440)	(-.752)	(-.354)	(-.905)	(-.648)
1/T(W)2	(.160)	(.135)	(.0676)	(.0436)	(.0954)
N(THE/DTH)					
A(THE)	-.636E-5	-.590E-5	-.599E-5	-.600E-5	-.597E-5
1/T(THE)1	-.502	-.357	-.150	-.135	-.276
1/T(THE)2	1.22	.822	1.32	1.70	.646
N(HD /DTH)					
A(HD)	.000152	.000164	.587E-4	.397E-4	.000145
1/T(HD)1	4.70	3.32	-.203	-.159	-.611
1/T(HD)2	(-.615)	(-.672)	-5.24	-9.48	-1.16
1/T(HD)3	(1.14)	(.951)	8.94	13.5	3.40
N(AZP/DTH)					
A(AZP)	.000141	.000131	.000133	.000133	.000133
1/T(AZP)1	-.0157	-.0235	-.00493	-.00251	-.0147
1/T(AZP)2	-.809	-.483	-.167	-.141	-.292
Z(AZP)1	-.0231	.0565	.0980	.115	.0370
W(AZP)1	2.81	2.70	4.93	6.55	2.91

F/C #	6	7	8	9	10
H	20 K	20 K	40 K	40 K	40 K
M	.550	.750	.500	.650	.800
DENOMINATOR					
1/T(DET)1	(.0498)	-.0195	(.0600)	(.0492)	.102
1/T(DET)2	(.0751)	.0339	(.0927)	(.0709)	-.134
Z(DET)1	.362	.382	.252	.259	.289
W(DET)1	2.60	3.77	1.44	1.93	2.45
NUMERATORS					
N(U /DTH)					
A(U)	.000842	.000842	.000842	.000842	.000842
1/T(U)1	.0261	.0199	.0273	.0225	.0206
Z(U)1	.417	.411	.473	.387	.347
W(U)1	2.31	3.78	1.46	1.98	2.95
N(W /DTH)					
A(W)	-.00345	-.00469	-.00290	-.00379	-.00468
1/T(W)1	(-.922)	.00970	(-.776)	(-.950)	-.000608
1/T(W)2	(.0541)	.0747	(.0752)	(.0521)	.595
N(THE/DTH)					
A(THE)	-.600E-5	-.601E-5	-.600E-5	-.601E-5	-.602E-5
1/T(THE)1	-.167	.0450	-.178	-.151	.438
1/T(THE)2	.937	1.37	.408	.522	.820
N(HD /DTH)					
A(HD)	.661E-4	.382E-4	.000166	.000103	.617E-4
1/T(HD)1	-.224	.0482	-.454	-.738	.610
1/T(HD)2	-4.95	-10.7	-1.18	-2.90	-6.06
1/T(HD)3	7.61	13.9	2.67	4.48	7.32
N(AZP/DTH)					
A(AZP)	.000133	.000133	.000133	.000133	.000134
1/T(AZP)1	-.00437	-.00191	-.0126	-.00611	-.00307
1/T(AZP)2	-.183	.0457	-.233	-.175	.542
Z(AZP)1	.0725	.0907	.0163	.0400	.0521
W(AZP)1	4.71	6.82	2.66	3.62	4.79

TABLE VII-6

JETSTAR LONGITUDINAL HANDLING QUALITIES PARAMETERS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.200	.230	.400	.525	.350	.550	.750	.500	.650	.900
STICK FIXED										
D(G)/D(U) (DEG/KT)	.0278	.0502	-.0215	-.0354	.0310	-.0122	-.0429	.0225	.0164	.00545
NZA (G/RAD)	6.32	5.24	16.0	28.0	5.86	14.5	30.0	4.90	8.64	15.0
DE/G (DEG/G)	10.8	10.4	3.29	1.94	8.64	3.53	1.85	9.43	5.70	3.49
CAP (RAD/SEC/SEC/G)	.425	.506	.478	.492	.444	.459	.468	.406	.425	.413
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	--	(35.4)	--	--	(5.17)
1/C(1/10)	1.70	1.40	1.47	1.42	1.04	1.06	1.13	.711	.731	.825

TABLE VII-7

JETSTAR LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
h	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
YV	-.140	-.100	-.175	-.229	-.0756	-.119	-.167	-.0469	-.0618	-.0761
YB	-31.2	-25	-78.0	-134.	-27.5	-67.8	-130.	-22.7	-38.9	-60.5
LB'	-4.05	-3.42	-5.27	-7.28	-3.23	-4.43	-4.93	-2.75	-2.93	-2.27
NB	1.34	1.10	3.30	5.47	1.21	2.99	5.63	1.02	1.75	2.66
LP'	-1.65	-.752	-1.30	-1.75	-.582	-.935	-1.34	-.380	-.492	-.635
NP'	-.249	-.173	-.164	-.187	-.121	-.119	-.137	-.0840	-.0758	-.0692
LR'	.517	.234	.181	.170	.169	.124	.0868	.105	.0936	.0551
NR'	-.190	-.172	-.261	-.333	-.125	-.178	-.252	-.0804	-.0994	-.120
Y*CA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
L'CA	2.21	1.04	3.14	5.71	1.10	2.88	5.83	.929	1.71	2.64
N'CA	-.00557	-.0864	-.0767	-.0524	-.0770	-.0759	-.0624	-.0716	-.0831	-.0720
Y*CR	.0340	.0244	.0424	.0557	.0184	.0289	0371	.0114	.0144	.0162
L'CR	1.11	.533	1.61	2.77	.568	1.40	2.43	444	.766	1.21
N'CR	-.644	-.580	-1.81	-3.12	-.618	-1.55	-2.66	-.511	-.836	-1.16

TABLE VII-8

JETSTAR AILERON TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
DENOMINATOR	-.0112	.00318	.00535	.00467	.000351	.00242	.00186	-.000500	-.000246	-.000201
1/T(DET)1	1.95	.558	1.45	1.89	.741	1.04	1.42	.495	.576	.593
1/T(DET)2	.0832	.0229	.0729	.0956	.0147	.0499	.0690	.00352	.0267	.0453
Z(DET)1	1.45	1.39	1.97	2.47	1.37	1.36	2.45	1.26	1.46	1.69
W(DET)1										
NUMERATORS										
N(B /DA)	.256	.286	.295	.321	.266	.302	.327	.254	.201	.265
A(B)	.0566	.0350	.0626	.0455	.0286	.0440	.0502	.0175	.0208	.0353
1/T(B)1	3.51	1.35	2.96	4.79	1.07	1.99	3.59	.676	.920	1.31
1/T(B)2										
N(P /DA)	2.21	1.04	3.14	5.71	1.10	2.88	5.83	.929	1.71	2.64
A(P)	-.0160	-.0242	-.00497	-.00255	-.0153	-.00441	-.00187	-.0133	-.00625	-.00304
1/T(P)1	.148	.153	.122	.120	.103	.0876	.0885	.0744	.0643	.0619
Z(P)1	1.17	.507	1.79	2.34	.992	1.70	2.37	.891	1.27	1.61
W(P)1										
N(R /DA)	-.00557	-.0864	-.0767	-.0524	-.0770	-.0759	-.0624	-.0716	-.0831	-.0720
A(R)	.673	.443	.717	.807	.404	.570	.700	.290	.369	.490
1/T(R)1	-1.13	-.823	-1.46	-1.72	-1.02	-1.62	-1.98	-1.04	-1.44	-1.79
1/T(R)2	99.9	3.30	8.92	23.2	3.00	6.64	15.6	2.26	3.19	4.59
1/T(R)3										
N(PHI/DA)	2.21	1.02	3.13	5.71	1.09	2.87	5.83	.914	1.70	2.64
A(PHI)	.129	.112	.116	.118	.0798	.0827	.0866	.0531	.0566	.0589
Z(PHI)1	1.17	.526	1.80	2.34	1.01	1.71	2.37	.914	1.28	1.62
W(PHI)1										
N(AYP/DA)	5.19	.566	5.83	12.5	.938	5.23	12.6	.639	2.27	4.74
A(AYP)	.0804	.0443	.0776	.0767	.0378	.0557	.0594	.0233	.0561	.0467
1/T(AYP)1	-2.34	-9.37	-2.44	-2.23	-4.35	-1.87	-1.07	-3.97	-1.85	-1.20
1/T(AYP)2	.0867	.221	.135	.138	.209	.111	.100	.277	.137	.0988
Z(AYP)1	1.28	1.22	1.97	2.51	1.20	1.81	2.41	1.07	1.36	1.67
W(AYP)1										

TABLE VII-9

JETSTAR RUDDER TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

A/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.260	.230	.400	.525	.350	.550	.750	.500	.650	.500
DENOMINATOR										
1/T(DET)1	-.0112	.00318	.00535	.00467	.000351	.00242	.00186	-.000600	-.000248	-.000201
1/T(DET)2	1.95	.558	1.45	1.89	.741	1.04	1.42	.499	.576	.680
Z(DET)1	.0832	.0229	.0729	.0856	.0147	.0499	.0690	.00352	.0267	.0453
W(DET)1	1.45	1.39	1.97	2.47	1.37	1.86	2.45	1.26	1.46	1.69
NUMERATORS										
N(B /DR)										
A(B)	.0340	.0244	.0424	.0557	.0184	.0289	.0371	.0114	.0144	.0162
1/T(B)1	-.0255	-.0312	-.00240	.000966	-.0201	-.00232	.00211	-.0164	-.00599	.00100
1/T(B)2	2.13	.870	1.43	1.90	.668	1.02	1.45	.434	.548	.698
1/T(B)3	22.5	27.7	45.4	58.5	38.5	57.4	74.6	51.7	64.2	77.1
N(P /DR)										
A(P)	1.11	.533	1.61	2.71	.568	1.40	2.43	.444	.766	1.21
1/T(P)1	-.0161	-.0246	-.00502	-.00259	-.0154	-.00444	-.00177	-.0134	-.00627	-.00303
Z(P)1	(.974)	(1.55)	(-1.58)	(-1.54)	(1.47)	(-1.34)	.252	(1.43)	(-1.19)	.0648
W(P)1	(-1.05)	(-1.67)	(1.67)	(1.77)	(-1.55)	(1.42)	.496	(-1.48)	(1.20)	.695
N(R /DR)										
A(R)	-.644	-.580	-1.81	-3.12	-.618	-1.55	-2.66	-.511	-.836	-1.16
1/T(R)1	2.25	.603	1.42	1.90	.604	1.01	-.0455	.363	.506	-.156
1/T(R)2	(.147)	(.134)	(.181)	(.287)	(.115)	(.161)	.131	(.0982)	(.120)	.186
1/T(R)3	(.333)	(.607)	(.344)	(.264)	(.553)	(.310)	1.47	(.579)	(.365)	.717
N(PHI/DR)										
A(PHI)	1.03	.418	1.48	2.63	.460	1.28	2.31	.341	.663	1.12
Z(PHI)1	(.933)	(1.65)	(1.68)	(-1.64)	(1.57)	(1.43)	.179	(1.58)	(1.26)	.0464
W(PHI)1	(-1.20)	(-2.09)	(-1.72)	(1.76)	(-1.85)	(-1.47)	.502	(-1.81)	(-1.34)	.721
N(AYP/DR)										
A(AYP)	-4.05	-5.33	-17.4	-30.0	-5.68	-14.6	-24.3	-4.77	-7.66	-10.3
1/T(AYP)1	-.0407	-.0666	-.00942	-.00207	-.0408	-.00693	.00234	-.0317	-.0118	.00207
1/T(AYP)2	3.95	.560	1.37	1.92	.453	.951	1.56	.269	.457	.765
Z(AYP)1	.233	.243	.111	.0876	.173	.0953	.0472	.126	.0872	.0394
W(AYP)1	1.20	1.57	2.20	2.83	1.59	2.07	2.68	1.50	1.67	1.87

TABLE [illegible]

[illegible] LATERAL-DIRECTIONAL [illegible] QUALITIES PARAMETERS

[illegible]

[illegible]

T/C #	1	2	3	[illegible]	5	7	8	9	10
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20 [illegible]	20 [illegible]	40 [illegible]	40 [illegible]	40 [illegible]
R	.200	[illegible]	.400	[illegible]	.550	.750	.500	.650	.800
DR PERIOD (SEC)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.29	3.72
T/C(1/2)	.757	.208	[illegible]	[illegible]	.453	.827	0319	.242	.411
SPIRAL (2) (SEC)	62.1	--	--	--	--	--	[illegible]66.	2795.	3443.
P(1)	[illegible]	[illegible]	1.60	.756	1.89	3.87	.753	1.53	3.47
P(2)	[illegible]	[illegible]	1.51	[illegible]	[illegible]	3.75	.365	1.53	3.36
P(3)	[illegible]	.709	1.36	1.03	2.40	3.84	1.17	2.31	3.65
P(2)/P(1)	[illegible]	.106	.945	[illegible]	.999	.962	.510	.976	.970
P(OSC)/P(AV)	.311	.122	.0705	[illegible]	.0659	.0173	.428	.114	.0200
W(PHI)/W(D)	.804	.664	.912	[illegible]	.919	.970	.724	.874	[illegible]
DEL-B-MAX	[illegible]	.368	.251	.356	.262	.203	.374	.339	.261
PHI TO BETA, PHASE	[illegible]	-327.	31.0	[illegible]	26.0	25.7	-340.	19.7	20.0
PHI TO BETA	[illegible]	1.48	1.13	1.50	1.11	.708	1.53	1.21	.693
PHI TO VE	[illegible]	.330	.145	.325	.153	.0714	.365	.222	.103

JETSTAR DATA SOURCES

Myers, Russell H., Jr., and Carl S. Cross, Jetstar Flight Evaluation, Air Force Flight Test Center Rept No. FTC-TDR-62-24C-140, Feb. 1963

Clark, Daniel C., and John Kroll, General Purpose Airborne Simulator — Conceptual Design Report, NASA CR-544, Aug. 1966

Flight Manual, USAF Series C-140A, C-140B, and VC-140B Aircraft, T. O. 1C-140A-1

Jetstar Handbook of Operating and Maintenance Instructions for USAF Models C-140A and VC-140B Aircraft, T. O. 1C-140A-2

SECTION VIII

CONVAIR 880M

CONVAIR 880M BACKGROUND

The Convair 880M is a medium-size four engine jet transport. Longitudinal and directional control consists of servo tab deflected elevators and rudder. Lateral control consists of servo tab deflected ailerons plus hydraulic actuated spoilers.

Elevator, aileron, and rudder transfer functions are in terms of respective primary surface deflections with tab losses included. Although the control system diagram shows a lag in the spoiler actuator, none was used in computing transfer functions.

CV-880M

Nominal Configuration

W = 155000 lb

c.g. at .25 $\bar{c}$, W.L. −19.2

I_x = 1510000 slug-ft^2

I_y = 2510000 slug-ft^2

I_z = 4100000 slug-ft^2

Power Approach Configuration

Flaps 30°

Gear Up

W = 126000 lb

c.g. at .195 $\bar{c}$, W.L. −19.2

I_x = 1150000 slug-ft^2

I_y = 2450000 slug-ft^2

I_z = 4070000 slug-ft^2

Landing Configuration

Same as Power Approach except:

Flaps 50°

Speed Brakes 8°

Gear Down

Flight Envelope

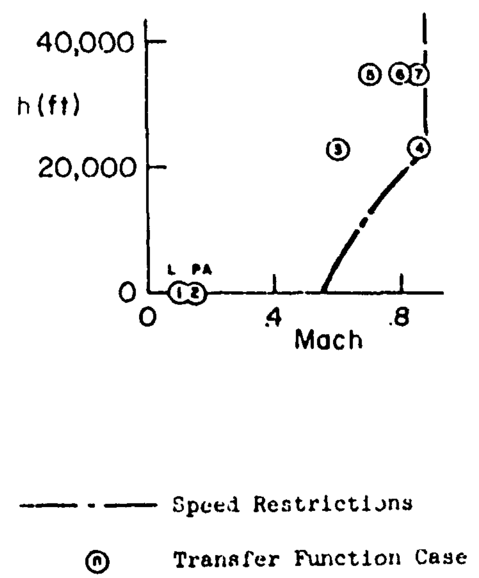


Figure VIII-1. Convair 880M Flight Conditions

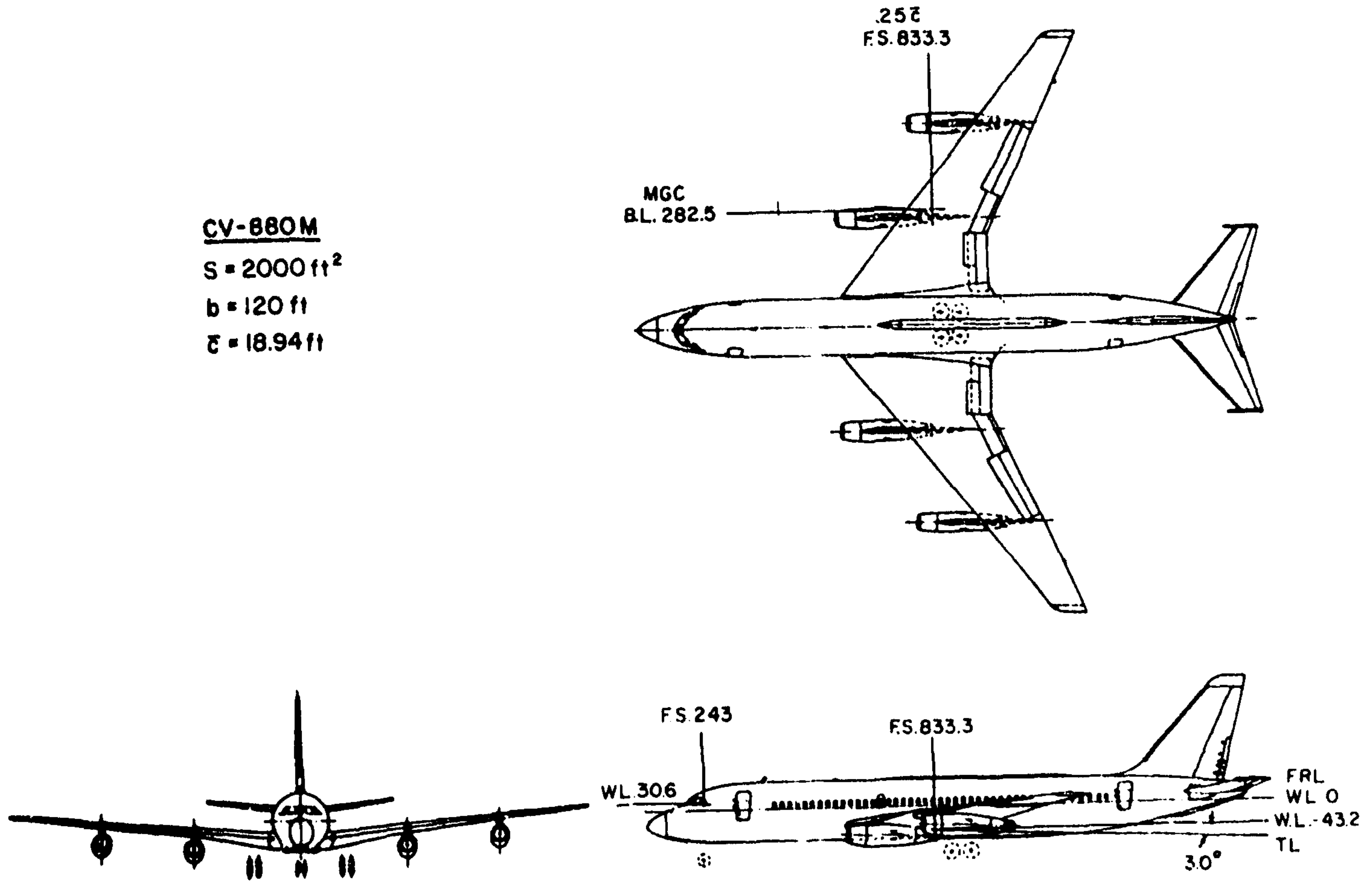


Figure VIII-2. Convair 880M General Arrangement

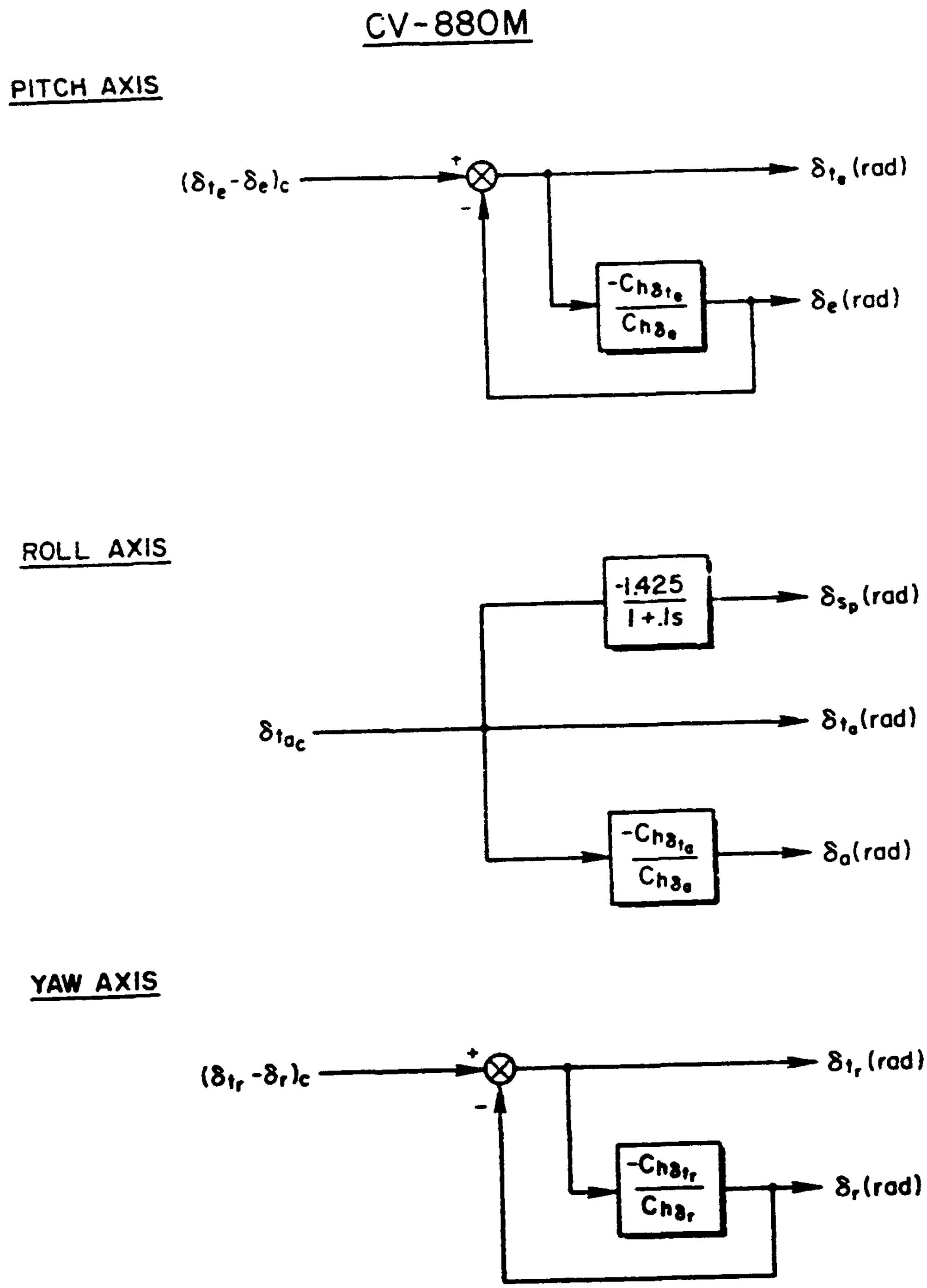


Figure VIII-3. CV-880M Control System

TABLE VIII-1

CV-880M

Longitudinal Non-Dimensional Stability Derivatives

Flight Condition	1	2	3	4	5	6	7
Configuration	L	PA					
Speed	134 KTAS	165 KTAS	.6M	.86M	.7M	.8M	.86M
Altitude	SL	SL	23K	23K	35K	35K	35K
α_0 (Deg)	5.2	4.3	5.3	2.8	8.3	4.7	4.0
C_L	1.03	0.68	0.36	0.175	0.454	0.347	0.301
C_D	0.154	0.080	0.022	0.019	0.025	0.024	0.025
C_{L_α} (1/rad)	4.66	4.52	4.28	4.41	4.62	4.8	4.9
C_{D_α} (1/rad)	0.43	0.27	0.14	0.07	0.18	0.15	0.13
C_{m_α} (1/rad)	−0.381	−0.903	−0.522	−0.572	−0.568	−0.65	−0.74
$C_{L_{\dot\alpha}}$ (1/rad)	2.7	2.7	2.44	2.5	2.75	2.75	2.9
C_{L_q} (1/rad)	7.92	7.72	6.76	6.37	7.51	7.5	7.62
$C_{m_{\dot\alpha}}$ (1/rad)	−4.17	−4.13	−4.16	−4.66	−4.4	−4.5	−4.6
C_{m_q} (1/rad)	−12.2	−12.1	−11.5	−11.8	−12.	−12.	−12.
$C_{L_{\delta_e}}$ (1/rad)	0.22	0.213	0.193	0.141	0.203	0.190	0.180
$C_{m_{\delta_e}}$ (1/rad)	−0.657	−0.637	−0.586	−0.438	−0.618	−0.57	−0.532
$C_{h_{\delta_e}}$ (1/rad)	−0.326	−0.328	−0.336	−0.278	−0.342	−0.31	−0.285
$C_{L_{\delta_{te}}}$ (1/rad)	0.055	0.0532	0.0482	0.0352	0.0508	0.047	0.0450
$C_{m_{\delta_{te}}}$ (1/rad)	−0.164	−0.159	−0.146	−0.11	−0.155	−0.14	−0.134
$C_{h_{\delta_{te}}}$ (1/rad)	−0.287	−0.285	−0.297	−0.343	−0.312	−0.335	−0.352

TABLE VIII-2

CV-880M

Lateral-Directional Non-Dimensional Derivatives
(Stability Axis System)

Flight Condition	1	2	3	4	5	6	7
Configuration	L	PA					
Speed	135 KTAS	165 KTAS	.6M	.86M	.7M	.8M	.86M
Altitude	SL	SL	23K	23K	35K	35K	35K
C_{y_β} (1/rad)	−1.015	−0.877	−0.758	−0.815	−0.807	−0.8125	−0.842
C_{l_β} (1/rad)	−0.239	−0.196	−0.163	−0.145	−0.181	−0.177	−0.179
C_{n_β} (1/rad)	0.145	0.139	0.128	0.122	0.129	0.129	0.133
C_{l_p} (1/rad)	−0.395	−0.381	−0.329	−0.243	−0.341	−0.312	−0.294
C_{n_p} (1/rad)	−0.067	−0.049	−0.0173	−0.0031	−0.023	−0.011	−0.0054
C_{l_r} (1/rad)	0.309	0.198	0.146	0.088	0.180	0.153	0.146
C_{n_r} (1/rad)	−0.218	−0.185	−0.163	−0.189	−0.166	−0.165	−0.165
$C_{y_{\delta_a}}$ (1/rad)	0	0	0.0019	0.0745	0.0044	0.00775	0.00975
$C_{l_{\delta_a}}$ (1/rad)	−0.0487	−0.0384	−0.0466	−0.0452	−0.0479	−0.0497	−0.0479
$C_{n_{\delta_a}}$ (1/rad)	0.01862	0.0172	0.00746	0.01061	0.007	0.00865	0.00975
$C_{h_{\delta_a}}$ (1/rad)	−0.607	−0.481	−0.236	−0.258	−0.2233	−0.2005	−0.258
$C_{y_{\delta_{ta}}}$ (1/rad)	0	0	0	0	0	0	0
$C_{l_{\delta_{ta}}}$ (1/rad)	−0.0072	−0.0056	−0.0068	−0.0068	−0.0071	−0.0075	−0.0071
$C_{n_{\delta_{ta}}}$ (1/rad)	0	0	0	0	0	0	0
$C_{h_{\delta_{ta}}}$ (1/rad)	−0.249	−0.227	−0.215	−0.2125	−0.226	−0.235	−0.213
$C_{y_{\delta_s}}$ (1/rad)	−0.078	−0.0315	−0.0189	−0.0175	−0.0189	−0.0189	−0.0175
$C_{l_{\delta_s}}$ (1/rad)	0.0805	0.0405	0.029	0.0281	0.0324	0.0329	0.0339
$C_{n_{\delta_s}}$ (1/rad)	0.0258	0.0129	0.01146	0.0109	0.00975	0.01004	0.00917
$C_{y_{\delta_r}}$ (1/rad)	0.223	0.2155	0.1904	0.1394	0.199	0.184	0.1685
$C_{l_{\delta_r}}$ (1/rad)	0.0207	0.0226	0.0176	0.0183	0.0165	0.0187	0.0193
$C_{n_{\delta_r}}$ (1/rad)	−0.0995	−0.0958	−0.0845	−0.0534	−0.0848	−0.0756	−0.0644
$C_{h_{\delta_r}}$ (1/rad)	−0.2140	−0.2125	−0.1626	−0.1844	−0.1345	−0.1491	−0.1924
$C_{y_{\delta_{tr}}}$ (1/rad)	0.0493	0.0467	0.0374	0.0215	0.0404	0.0355	0.0316
$C_{l_{\delta_{tr}}}$ (1/rad)	0.0021	0.0027	0.0016	0.0018	0.0014	0.0019	0.0020
$C_{n_{\delta_{tr}}}$ (1/rad)	−0.020	−0.019	−0.015	−0.0077	−0.016	−0.0134	−0.011
$C_{h_{\delta_{tr}}}$ (1/rad)	−0.255	−0.253	−0.267	−0.254	−0.27	−0.267	−0.265

TABLE VIII-3

CV-880M DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

F/C #	1	2	3	4	5	6	7
H(FT)	SL	SL	23 K	23 K	35 K	35 K	35 K
M(-)	.203	.249	.600	.860	.700	.800	.860
VTO(FPS)	226.	278.	615.	881.	681.	779.	837.
VTO(KTAS)	134.	165.	364.	522.	404.	461.	496.
VTO(KCAS)	134.	165.	259.	381.	235.	272.	295.
W(LBS)	126007.	126007.	155008.	155008.	155008.	155008.	155008.
C.G.(MGC)	.195	.195	.250	.250	.250	.250	.250
IX (SLUG-FT SQ)	.115E+7	.115E+7	.151E+7	.151E+7	.151E+7	.151E+7	.151E+7
IY (SLUG-FT SQ)	.245E+7	.245E+7	.251E+7	.251E+7	.251E+7	.251E+7	.251E+7
IZ (SLUG-FT SQ)	.359E+7	.359E+7	.410E+7	.410E+7	.410E+7	.410E+7	.410E+7
IXZ(SLUG-FT SQ)	0.	0.	0.	0.	0.	0.	0.
EPSILON(DEG)	0.	0.	0.	0.	0.	0.	0.
Q(PSF)	60.8	92.2	216.	444.	171.	224.	259.
QC(PSF)	61.4	93.6	236.	532.	193.	262.	310.
ALPHA(DEG)	5.20	4.32	5.30	2.80	8.30	4.65	4.04
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	48.1	48.1	49.1	49.1	49.1	49.1	49.1
LZP(FT)	-4.15	-4.15	-4.15	-4.15	-4.15	-4.15	-4.15
ITH(DEG)	3.00	3.00	3.00	3.00	3.00	3.00	3.00
XI(DEG)	3.00	3.00	3.00	3.00	3.00	3.00	3.00
LTH(FT)	2.00	2.00	2.00	2.00	2.00	2.00	2.00

TABLE VIII-4

CV-880M LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.600	.860	.700	.800	.860
XU *	-.0292	-.0192	-.00501	-.00764	-.00799	-.00468	-.00512
ZU *	-.226	-.173	-.0473	-.0283	-.000148	-.0364	-.0330
MU *	.894E-5	.000262	.000231	.000182	.000325	.000207	.000221
XW	.140	.127	.0899	.0669	.0929	.0699	.0552
ZW	-.674	-.785	-.629	-.927	-.501	-.577	-.632
MW	-.00159	-.00461	-.00276	-.00434	-.00245	-.00281	-.00344
ZWD	-.0154	-.0154	-.00544	-.00561	-.00391	-.00396	-.00419
ZQ	-10.2	-12.3	-9.26	-12.6	-7.26	-8.42	-9.21
MWD	-.000723	-.000717	-.000338	-.000380	-.000235	-.000237	-.000242
MQ	-.481	-.585	-.578	-.850	-.431	-.493	-.530
XDE	.450	.539	1.14	1.01	1.52	1.10	1.09
ZDE	-4.95	-7.13	-12.3	-20.6	-10.4	-13.5	-15.4
MDE	-.443	-.647	-1.37	-2.34	-1.17	-1.49	-1.65
XDTH	.000255	.000255	.000207	.000207	.000207	.000207	.000207
ZDTH	-.134E-4	-.134E-4	-.109E-4	-.109E-4	-.109E-4	-.109E-4	-.109E-4
MDTH	.816E-6	.816E-6	.797E-6	.797E-6	.797E-6	.797E-6	.797E-6

TABLE VIII-5

CV-880M ELEVATOR DIMENSIONAL DERIVATIVES

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.600	.860	.700	.800	.860
DENOMINATOR							
Z(DET)1	.120	.0628	.0361	.0815	.0351	.0443	.0513
W(DET)1	.131	.137	.0659	.0452	.0528	.0538	.0504
Z(DET)2	.793	.599	.494	.492	.400	.399	.381
W(DET)2	.818	1.29	1.42	2.13	1.37	1.56	1.78
NUMERATORS							
N(U /DE)							
A(U)	.443	.531	1.14	1.00	1.51	1.09	1.08
1/T(U)1	18.1	23.1	67.2	58.5	74.9	84.3	88.2
Z(U)1	.345	.304	.192	.187	.236	.212	.209
W(U)1	1.08	1.11	.593	.822	.401	.533	.577
N(W /DE)							
A(W)	-4.87	-7.03	-12.3	-20.5	-10.4	-13.5	-15.4
1/T(W)1	19.7	24.7	67.7	99.2	75.3	84.9	98.7
Z(W)1	.0965	.0783	.0439	.105	.0554	.0533	.0641
W(W)1	.180	.143	.0508	.0325	.00961	.0397	.0366
N(THE/DE)							
A(THE)	-.439	-.642	-1.37	-2.33	-1.17	-1.48	-1.64
1/T(THE)1	.0841	.0505	.0121	.00977	.00815	.00932	.00875
1/T(THE)2	.597	.697	.596	.884	.477	.545	.595
N(HD /DE)							
A(HD)	4.89	7.05	12.3	20.5	10.5	13.5	15.4
1/T(HD)1	.0161	.0124	.00289	.00675	.00101	.00304	.00377
1/T(HD)2	3.34	3.94	6.11	9.02	5.78	6.56	7.00
1/T(HD)3	-3.89	-4.65	-6.72	-9.82	-6.30	-7.15	-7.63
N(AZP/DE)							
A(AZP)	16.3	23.9	54.9	93.5	46.9	59.3	65.3
1/T(AZP)1	-.0250	-.0154	-.00636	-.00200	-.00703	-.00428	-.00336
1/T(AZP)2	.0405	.0277	.00921	.00874	.00798	.00730	.00710
Z(AZP)1	.260	.250	.145	.143	.125	.124	.125
W(AZP)1	1.97	2.32	3.02	4.40	2.83	3.26	3.54

TABLE VIII-6

CV-880M THRUST DIMENSIONAL DERIVATIVES

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.600	.86C	.700	.800	.86J
DENOMINATOR							
Z(DET)1	.120	.0628	.0361	.0815	.0351	.0443	.0513
W(DET)1	.131	.137	.0659	.0452	.0528	.0538	.0504
Z(DET)2	.793	.599	.494	.493	.400	.399	.381
W(DET)2	.818	1.29	1.42	2.13	1.37	1.56	1.78
NUMERATORS							
N(U /DTH)							
A(U)	.000255	.000255	.000207	.000207	.000207	.000207	.000207
1/T(U)1	-.104	-.0586	-.0453	-.0284	-.0438	-.0348	-.0293
Z(U)1	.776	.590	.435	.461	.281	.335	.328
W(U)1	.858	1.30	1.42	2.13	1.34	1.55	1.77
N(W /DTH)							
A(W)	-.128E-4	-.129E-4	-.107E-4	-.107E-4	-.1C7E-4	-.108E-4	-.108E-4
1/T(W)1	-8.64	-12.9	-43.6	-62.9	-.C0906	-55.8	-60.1
Z(W)1	-.400	-.0568	.590	.811	(.C937)	.750	.809
W(W)1	.228	.158	.C456	.0295	(-49.5)	.0350	.0317
N(THE/DTH)							
A(THE)	.842E-6	.839E-6	.807E-6	.805E-6	.806E-6	.803E-6	.803E-6
1/T(THE)1	(.955)	(.838)	.130	.0888	.0850	.111	.113
1/T(THE)2	(.398)	(.580)	.598	.943	.536	.559	.625
N(HD /DTH)							
A(HD)	.359E-4	.320E-4	.258E-4	.209E-4	.405E-4	.275E-4	.253E-4
1/T(HD)1	.137	.310	.0973	.C776	.0468	.0865	.0906
Z(HD)1	.658	.501	.249	.21C	.187	.197	.188
W(HD)1	2.15	2.70	3.52	5.96	2.92	3.92	4.44
N(AZP/DTH)							
A(AZP)	-.533E-4	-.532E-4	-.503E-4	-.503E-4	-.503E-4	-.502E-4	-.502E-4
1/T(AZP)1	-.0155	-.00919	-.CC459	-.CC181	-.C0686	-.00344	-.00276
1/T(AZP)2	.163	.353	.113	.C849	.C864	.0991	.102
Z(AZP)1	.549	.416	.201	.185	.145	.165	.162
W(AZP)1	1.70	1.99	2.56	3.72	2.39	2.76	3.01

TABLE VIII-7

CV-880M LONGITUDINAL HANDLING QUALITIES PARAMETERS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.600	.860	.700	.800	.860
STICK FIXED							
D(G)/D(U) (DEG/KT)	-.0488	-.0376	-.00873	-.0203	-.00306	-.00918	-.0114
NZA (G/RAD)	4.69	6.47	11.6	24.4	10.1	13.3	15.6
DE/G (DEG/G)	18.8	23.5	7.36	4.60	5.03	7.09	7.11
CAP (RAD/SEC/SEC/G)	.144	.264	.176	.187	.184	.184	.204
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	--	--
1/C(1/10)	3.55	2.04	1.55	1.55	1.19	1.19	1.13

TABLE VIII-8

CV-880M LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.600	.860	.700	.800	.860
YV	-.139	-.148	-.115	-.170	-.0842	-.0969	-.108
YB	-31.5	-41.3	-70.7	-150.	-57.4	-75.5	-90.4
LB'	-3.19	-3.06	-5.98	-10.6	-5.38	-6.64	-7.72
NB'	.499	.763	1.42	2.98	1.02	1.50	1.82
LP'	-1.39	-1.62	-1.14	-1.15	-.863	-.884	-.893
NP'	-.113	-.0857	-.0416	-.0105	-.0453	-.0240	-.0165
LR'	.980	.756	.434	.409	.364	.384	.401
NR'	-.215	-.232	-.188	-.327	-.130	-.156	-.159
Y*DA	-.0371	-.0161	-.00458	-.00774	-.00303	-.00364	-.00512
L'DA	3.84	2.81	2.85	6.00	2.30	2.93	4.00
N'DA	.401	.202	.230	.321	.192	.142	.195
Y*DR	.0250	.0298	.0245	.0259	.0187	.0196	.0187
L'DR	.335	.507	.808	1.36	.563	.824	.892
N'DR	-.327	-.480	-.926	-1.22	-.747	-.870	-.829

TABLE VIII-9

CV-880M AILERON TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.500	.860	.700	.800	.860
DENOMINATOR							
1/T(DET)1	.00912	.0123	.00785	.0184	.00553	.00790	.00837
1/T(DET)2	1.50	1.69	1.12	1.17	.792	.871	.875
Z(DET)1	.119	.136	.112	.132	.105	.0903	.0931
W(DET)1	1.02	1.11	1.41	1.88	1.33	1.43	1.54
NUMERATORS							
N(B /DA)							
A(B)	-.0371	-.0161	-.00456	-.00774	-.00303	-.00364	-.00512
1/T(B)1	.316	.315	-8.17	-1.26	.294	.253	-17.1
Z(B)1	(-2.74)	(-3.87)	.981	(1.68)	(.423)	(.868)	.987
W(B)1	(5.42)	(4.78)	.952	(4.71)	(-46.9)	(-26.6)	.578
N(P /DA)							
A(P)	3.84	2.81	2.85	6.00	2.30	2.93	4.00
1/T(P)1	-.0122	-.00835	-.00479	-.00176	-.00682	-.00333	-.00269
Z(P)1	.266	.223	.127	.141	.107	.105	.104
W(P)1	.938	1.05	1.39	1.90	1.21	1.35	1.49
N(R /DA)							
A(R)	.401	.202	.230	.321	.192	.142	.195
1/T(R)1	.951	1.05	.576	.786	.325	.504	.549
Z(R)1	-.251	-.211	.0451	.0865	.0193	-.0167	.0190
W(R)1	1.09	1.26	1.46	1.76	1.59	1.75	1.77
N(PHI/DA)							
A(PHI)	3.87	2.82	2.87	6.01	2.33	2.44	4.01
Z(PHI)1	.261	.219	.126	.141	.104	.104	.103
W(PHI)1	.934	1.04	1.39	1.90	1.22	1.35	1.49
N(AYP/DA)							
A(AYP)	26.8	16.9	20.3	33.8	16.9	16.3	21.9
1/T(AYP)1	.360	.352	-.210	-.273	.180	.196	.223
1/T(AYP)2	-.596	-.561	.292	.363	-.214	-.269	-.244
Z(AYP)1	.159	.152	.118	.133	.108	.105	.104
W(AYP)1	.987	1.09	1.40	1.90	1.26	1.38	1.51

TABLE VIII-1C

CV-880M RUDDER TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.600	.860	.700	.800	.860
DENOMINATOR							
1/T(DET)1	.00912	.0123	.00789	.0184	.0553	.00790	.00837
1/T(DET)2	1.50	1.69	1.12	1.17	.792	.871	.875
Z(DET)1	.119	.136	.112	.132	.105	.0903	.0931
W(DET)1	1.02	1.11	1.41	1.88	1.33	1.43	1.54
NUMERATORS							
N(B /DR)							
A(B)	.0250	.0298	.0245	.0255	.0187	.0196	.0187
1/T(B)1	-.0753	-.0398	-.0164	-.00255	-.0205	-.0136	-.0115
1/T(B)2	1.53	1.71	1.12	1.17	.819	.874	.880
1/T(B)3	14.4	17.5	41.0	49.5	44.1	47.9	47.9
N(P /DR)							
A(P)	.335	.507	.806	1.36	.563	.824	.892
1/T(P)1	-.0123	-.00846	-.00481	-.00177	-.00685	-.00334	-.00270
1/T(P)2	1.29	1.50	2.16	2.53	2.26	2.21	2.20
1/T(P)3	-2.12	-2.06	-2.54	-2.60	-2.70	-2.51	-2.45
N(R /DR)							
A(R)	-.327	-.480	-.926	-1.22	-.747	-.870	-.829
1/T(R)1	1.53	1.71	.974	1.05	.444	.721	.751
Z(R)1	.0813	.114	.275	.221	.367	.228	.209
W(R)1	.498	.462	.504	.495	.698	.547	.543
N(PHI/DR)							
A(PHI)	.305	.471	.720	1.30	.454	.753	.834
1/T(PHI)1	1.28	1.49	2.22	2.56	2.42	2.26	2.24
1/T(PHI)2	-2.36	-2.24	-2.79	-2.65	-3.20	-2.70	-2.59
N(AYP/DR)							
A(AYP)	-8.68	-12.7	-27.1	-31.4	-21.6	-24.1	-21.4
1/T(AYP)1	-.0930	-.0595	-.0270	-.0161	-.0303	-.0238	-.0226
1/T(AYP)2	1.63	1.78	.859	.956	.516	.634	.654
Z(AYP)1	.227	.204	.184	.103	.184	.146	.134
W(AYP)1	1.03	1.12	1.51	2.24	1.63	1.70	1.85

TABLE VIII-11

CV-880M LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.600	.860	.700	.800	.860
DR PERIOD (SEC)	6.20	5.69	4.49	3.37	4.75	4.41	4.10
1/C(1/2)	1.08	1.24	1.02	1.21	.956	.822	.848
SPIRAL (2) (SEC)	--	--	--	--	--	--	--
P(1)	2.52	1.56	2.36	4.85	2.37	2.95	4.11
P(2)	1.57	1.19	--	4.85	2.12	2.72	3.92
P(3)	2.12	1.38	--	4.85	2.21	2.79	3.95
P(2)/P(1)	.624	.764	--	1.00	.893	.924	.953
P(OSC)/P(AV)	.192	.105	--	.107E-4	.0395	.0263	.0143
W(PHI)/W(D)	.915	.937	.984	1.01	.914	.947	.967
DEL-B-MAX	.669	.272	.0578	.0237	.140	.105	.0839
PHI TO BETA, PHASE	-302.	-304.	34.1	23.1	-333.	-333.	24.9
PHI TO BETA	1.96	1.94	2.45	2.68	2.64	2.85	2.90
PHI TO VE	.497	.400	.329	.251	.398	.376	.357

CV-880M DATA SOURCES

McNeill, Walter E., Calculated and Flight Measured Handling-Qualities Factors of Three Subsonic Jet Transports, NASA TN D-4832, Nov. 1968.

Brooks, Peter W., The World's Airliners, London, Putnam, 1962.

SECTION IX

BOEING 747

BOEING 747 BACKGROUND

The Boeing 747 is a very large four-fanjet intercontinental transport designed to operate from existing international airports. To obtain the necessary low speed characteristics the wing has triple-slotted trailing flaps and Krueger type leading edge flaps. The Krueger flaps outboard of the inboard nacelle are variable cambered and slotted while the inboard Krueger flaps are standard unslotted. Longitudinal control is obtained through four elevator segments and a movable stabilizer. The lateral control employs five spoiler panels, an inboard aileron between the inboard and outboard flaps, and an outboard aileron which operates with flaps down only on each wing. The five spoiler panels on each wing also operate symmetrically as speedbrakes in conjunction with the most inboard sixth spoiler panel. Directional control is obtained from two rudder segments.

Information for this aircraft was obtained solely from a 747 simulator description (Boeing D6-30643).

Nominal Configuration

Load to Max Zero Fuel Weight

TOGW less 40% Fuel

W = 636,600 lb

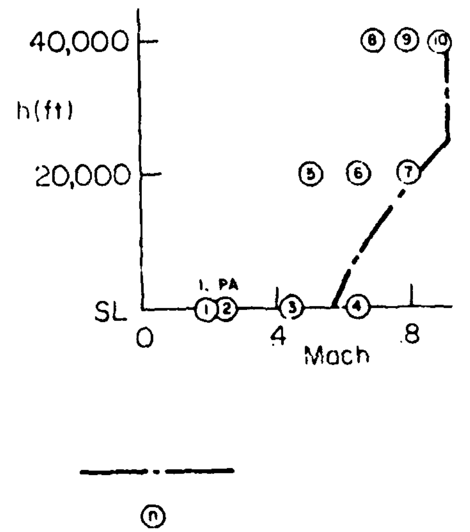
c.g. at 0.25 $\bar{c}$

I_x = 18.2×10^6 slug-ft^2

I_y = 33.1×10^6 slug-ft^2 Body Axis

I_z = 49.7×10^6 slug-ft^2

I_{xz} = 0.97×10^6 slug-ft^2



Power Approach Configuration

Max Landing Weight

20° Flaps

Gear Up

1.4 V_s

W = 564,000 lb

c.g. at 0.25 $\bar{c}$

I_x = 13.7×10^6 slug-ft^2

I_y = 30.5×10^6 slug-ft^2 Body Axis

I_z = 43.1×10^6 slug-ft^2

I_{xz} = 0.825×10^6 slug-ft^2

Landing Configuration

Same as Power Approach except:

30° Flaps

Gear Down

1.3 V_s

Figure IX-1. B-747 Flight Conditions

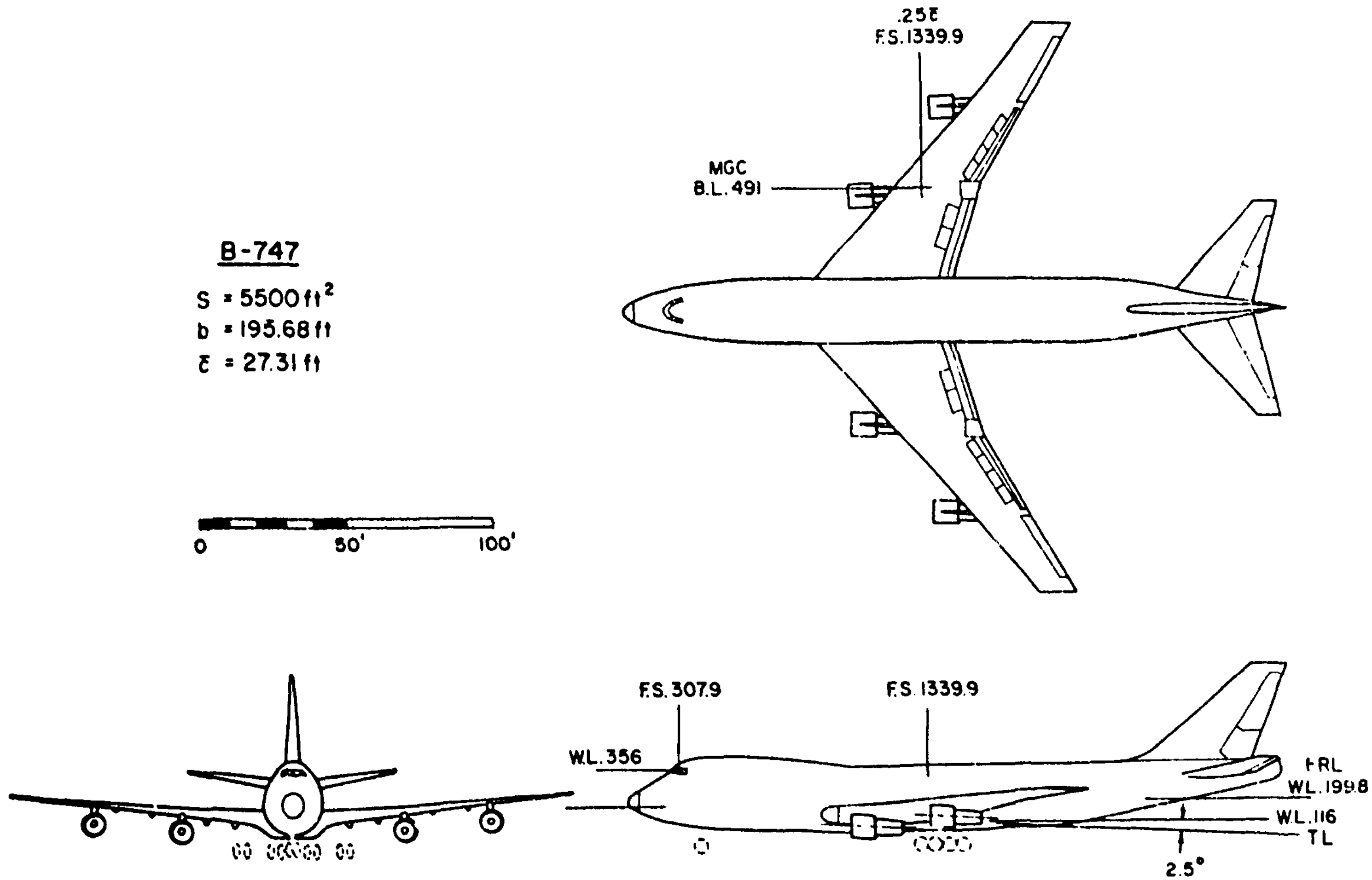
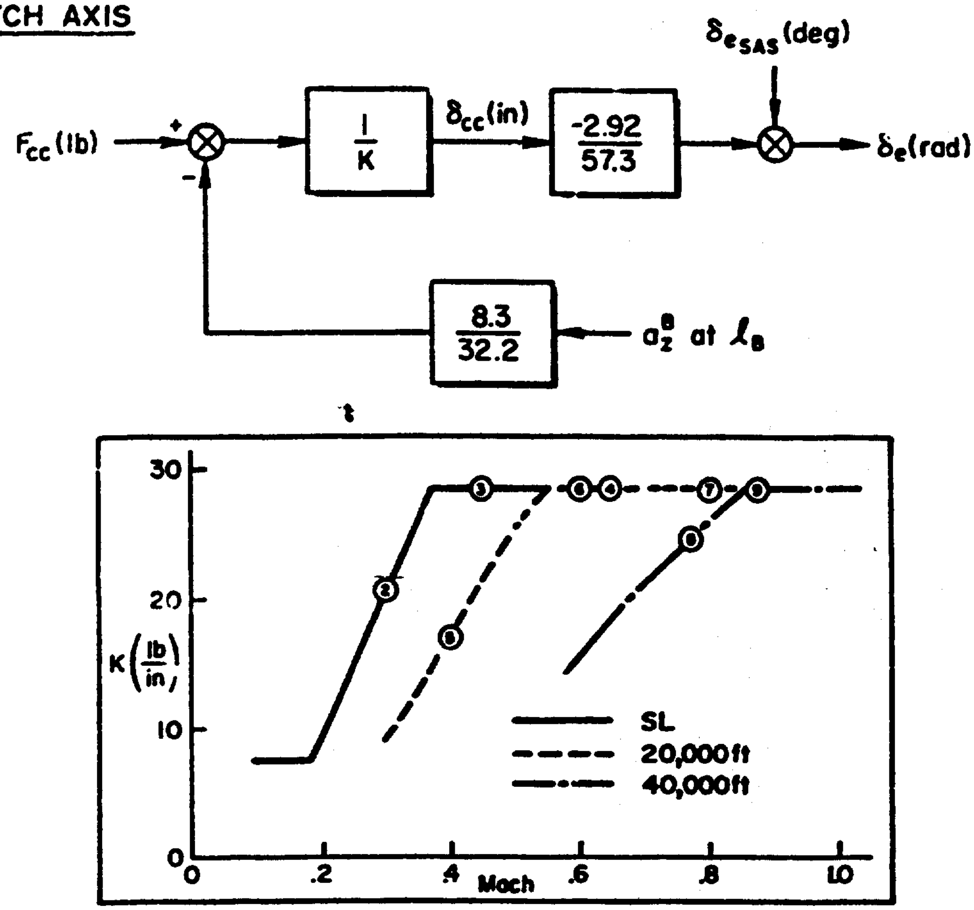


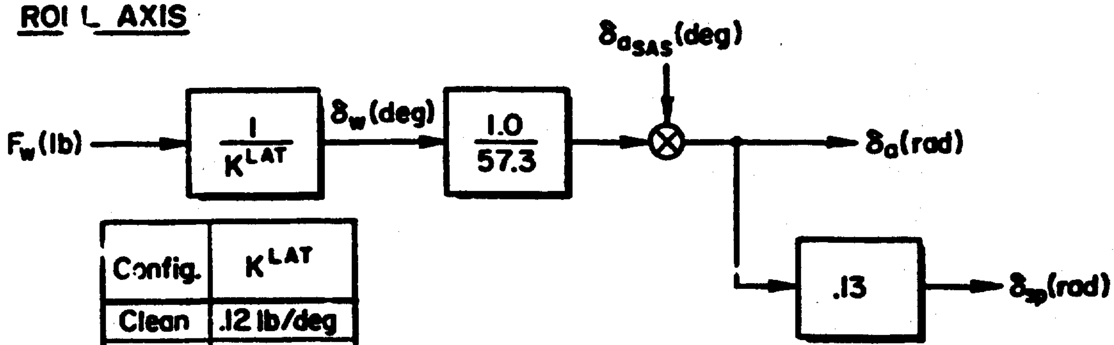
Figure IX-2. B-747 General Arrangement

C-5A

PITCH AXIS



ROLL AXIS



Config.	K^{LAT}
Clean	.12 lb/deg
PA	.155 lb/deg

YAW AXIS

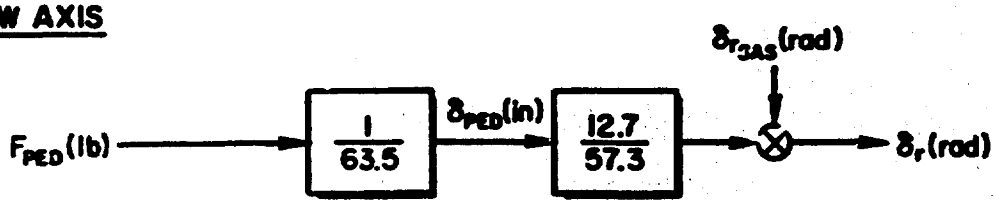
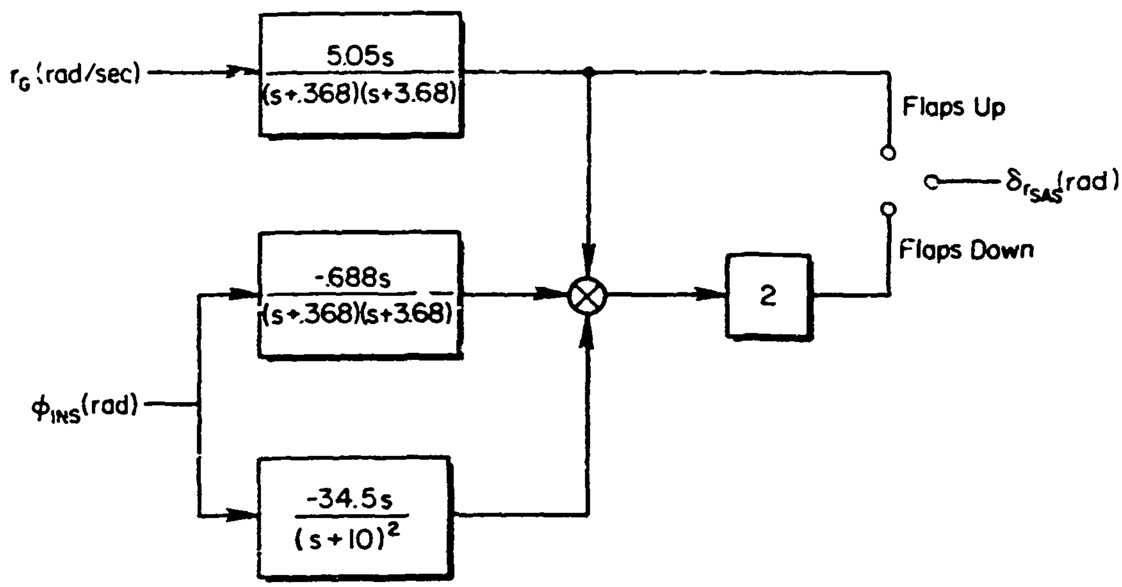


Figure X-3. C-5A Control System

B-747

YAW SAS



$$r \;\; = r$$

$$\phi_{INS} = \int p \, dt$$

(Gyro and INS Aligned with FRL)

Figure IX-4. B-747 SAS

TABLE IX-1

B-747

Landing Configuration Non-Dimensional Derivatives

h = sea level

V_{T_o} = 131 KTAS

α_o = 8.5°

δ_s = -6.3°

Longitudinal		Lateral-Directional	
C_L	= 1.76	C_{y_β}	= −1.08/rad
C_D	= .263	C_{ℓ_β}	= −.281/rad
C_{L_α}	= 5.67/rad	C_{n_β}	= .184/rad
C_{D_α}	= 1.13/rad	C_{ℓ_p}	= −.502/rad
C_{m_α}	= −1.45/rad	C_{n_p}	= −.222/rad
$C_{L_{\dot\alpha}}$	= −6.7/rad	C_{ℓ_r}	= .195/rad
$C_{m_{\dot\alpha}}$	= −3.3/rad	C_{n_r}	= −.36/rad
C_{L_q}	= 5.65/rad	$C_{\ell_{\delta_a}}$	= .0530/rad
C_{m_q}	= −21.4/rad	$C_{n_{\delta_a}}$	= .0083/rad
C_{L_M}	= −1.1	$C_{y_{\delta_r}}$	= .179/rad
C_{m_M}	= .36	$C_{\ell_{\delta_r}}$	= 0
$C_{L_{\delta_e}}$	= .356/rad	$C_{n_{\delta_r}}$	= −.112/rad
$C_{m_{\delta_e}}$	= −1.40/rad		

δ_a = total deflection of right inboard aileron plus left inboard aileron with the effect of outboard ailerons included

TABLE IX-2

B-747

Power Approach Configuration
Non-Dimensional Derivatives

h = sea level

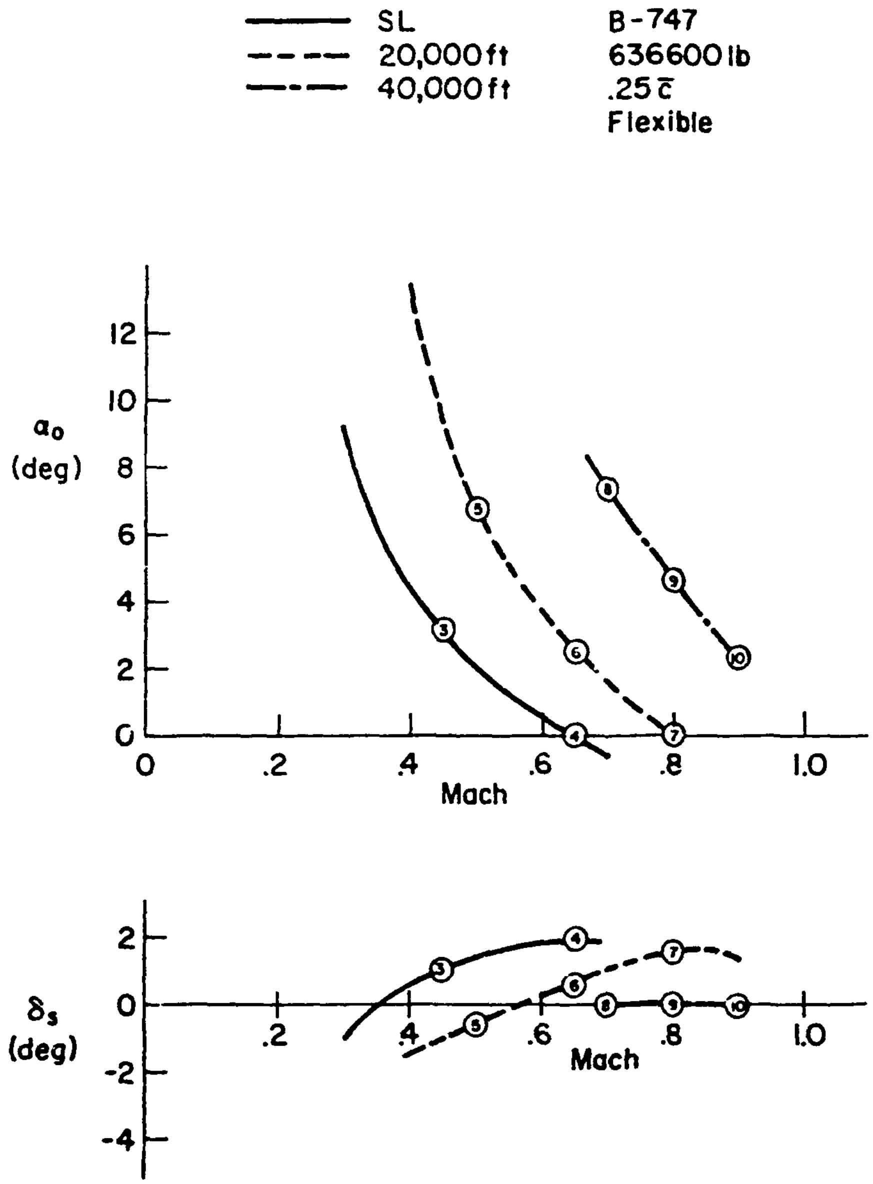
V_{T_o} = 165 KTAS

α_o = 5.7°

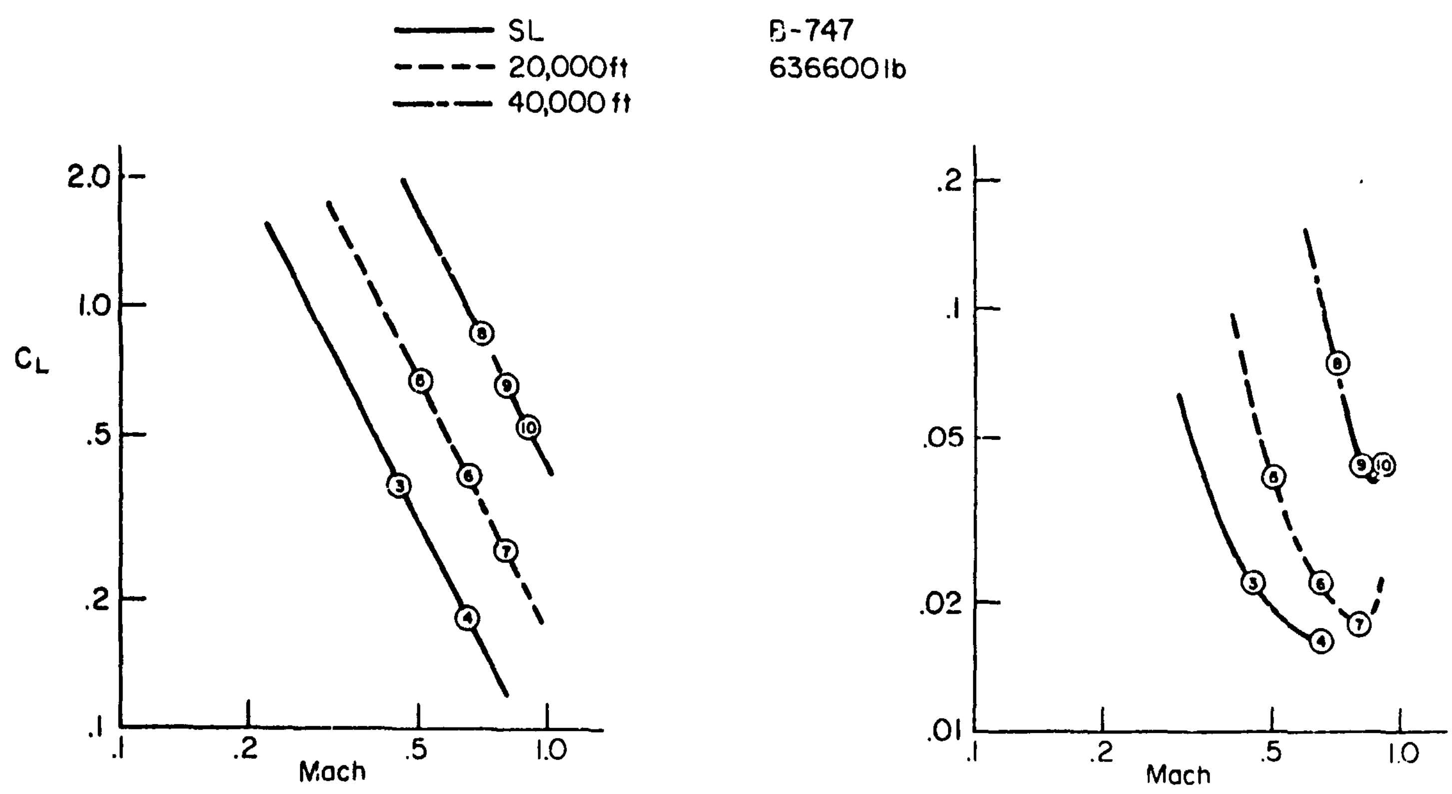
δ_s = −2.1°

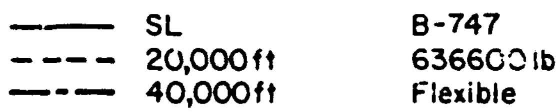
Longitudinal		Lateral-Directional	
C_L	= 1.11	C_{y_β}	= −.96/rad
C_D	= .102	C_{ℓ_β}	= −.221/rad
C_{L_α}	= 5.70/rad	C_{n_β}	= .150/rad
C_{D_α}	= .66/rad	C_{ℓ_p}	= −.45/rad
C_{m_α}	= −1.26/rad	C_{n_p}	= −.121/rad
$C_{L_{\dot\alpha}}$	= −6.7/rad	C_{ℓ_r}	= .101/rad
$C_{m_{\dot\alpha}}$	= −3.2/rad	C_{n_r}	= −.30/rad
C_{L_q}	= 5.4/rad	$C_{\ell_{\delta_a}}$	= .0461/rad
C_{m_q}	= −20.8/rad	$C_{n_{\delta_a}}$	= .0064/rad
C_{L_M}	= −.81	$C_{y_{\delta_r}}$	= .175/rad
C_{m_M}	= .27	$C_{\ell_{\delta_r}}$	= .007/rad
$C_{L_{\delta_e}}$	= .338/rad	$C_{n_{\delta_r}}$	= −.109/rad
$C_{m_{\delta_e}}$	= −1.34/rad		

δ_a = total deflection of right inboard aileron plus left inboard aileron with the effect of outboard ailerons included

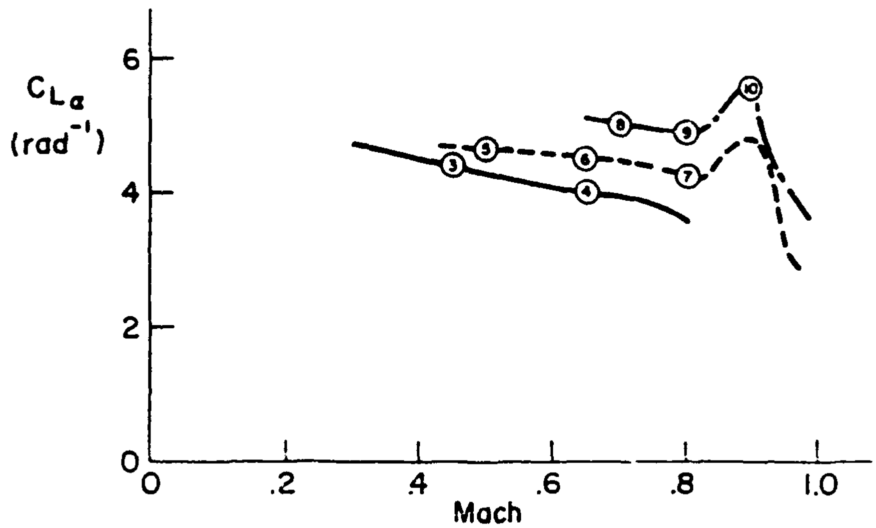


SL
20,000 ft
40,000 ft
B-747
636600 lb
.25 $\bar{c}$
Flexible
α_0 (deg)
Mach
δ_s (deg)
Mach

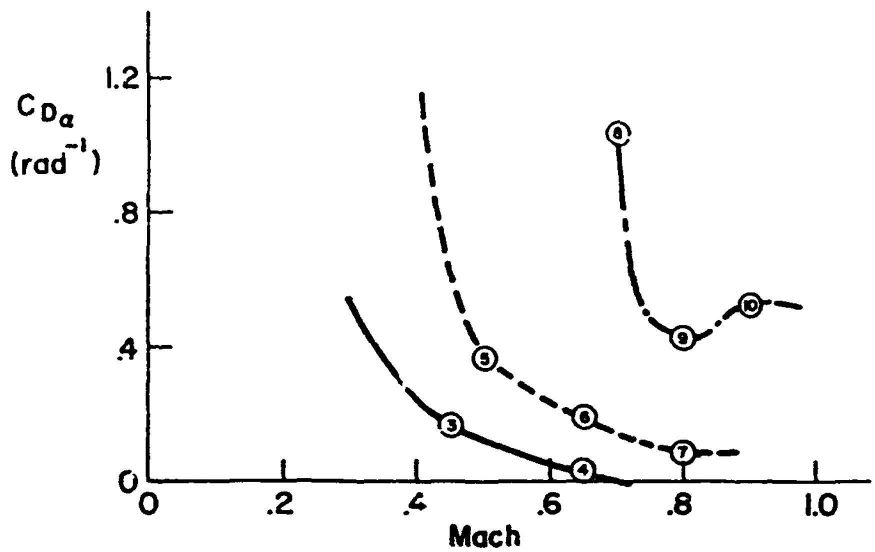

SL
20,000 ft
40,000 ft
B-747
636600 lb
C_L
2.0
1.0
.5
.2
.1
.2
.5
1.0
Mach
.2
.1
.05
.02
.01
.1
.2
.5
1.0
Mach



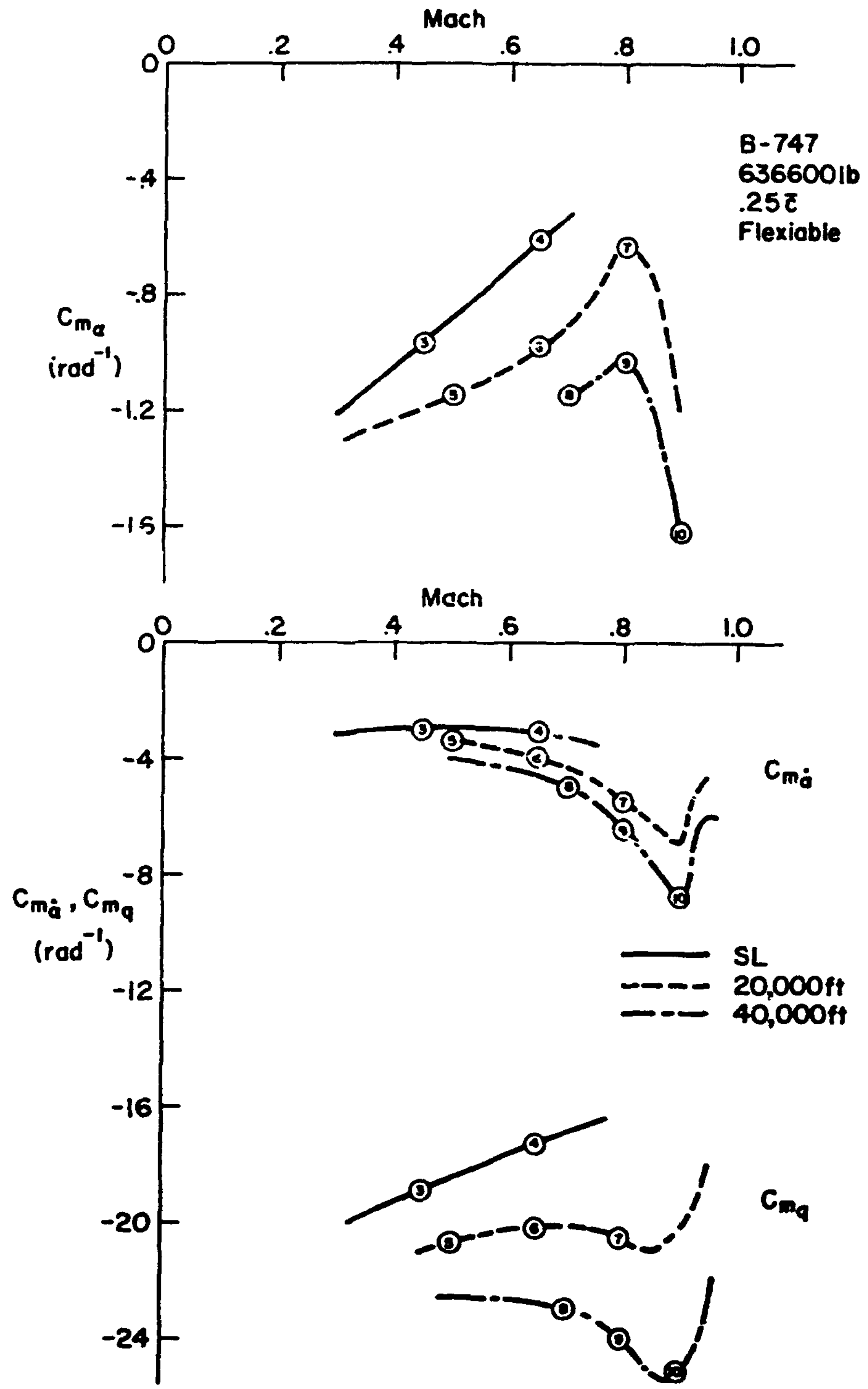
SL
20,000 ft
40,000 ft
B-747
636600 lb
Flexible



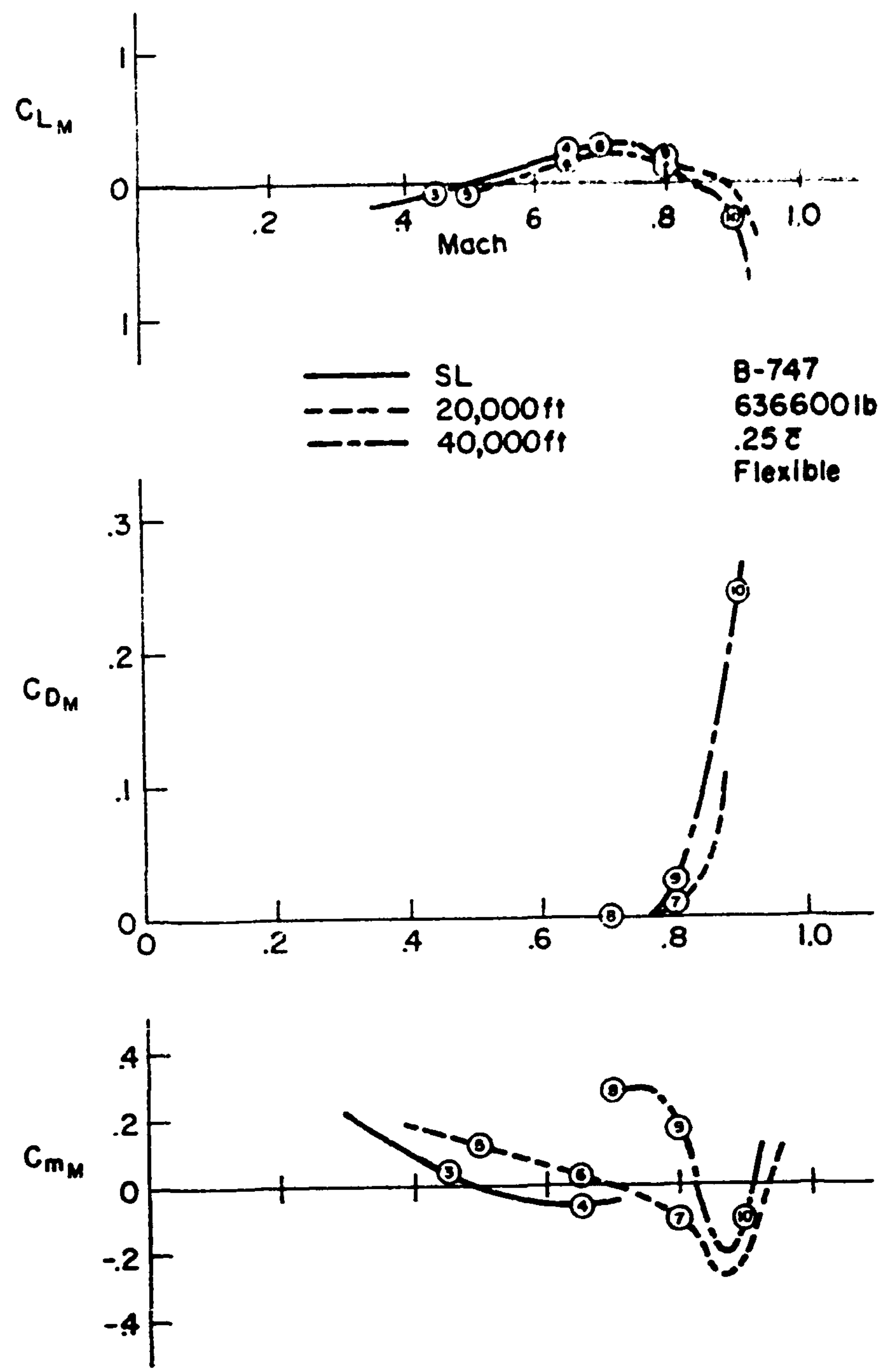
C_{L_α} (rad^{-1})
Mach
0
2
4
6
.2
.4
.6
.8
1.0



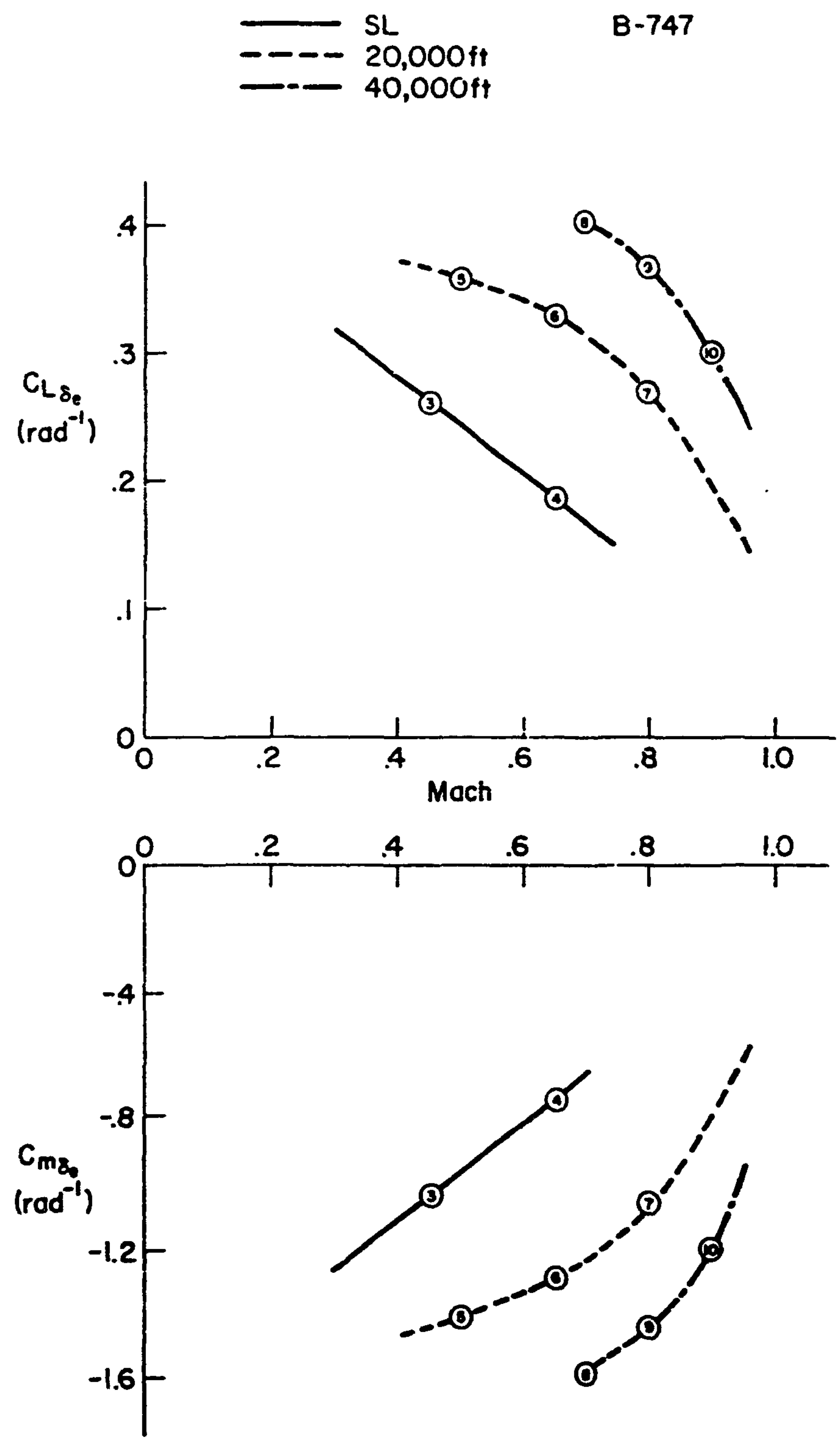
C_{D_α} (rad^{-1})
Mach
0
.4
.8
1.2
.2
.4
.6
.8
1.0



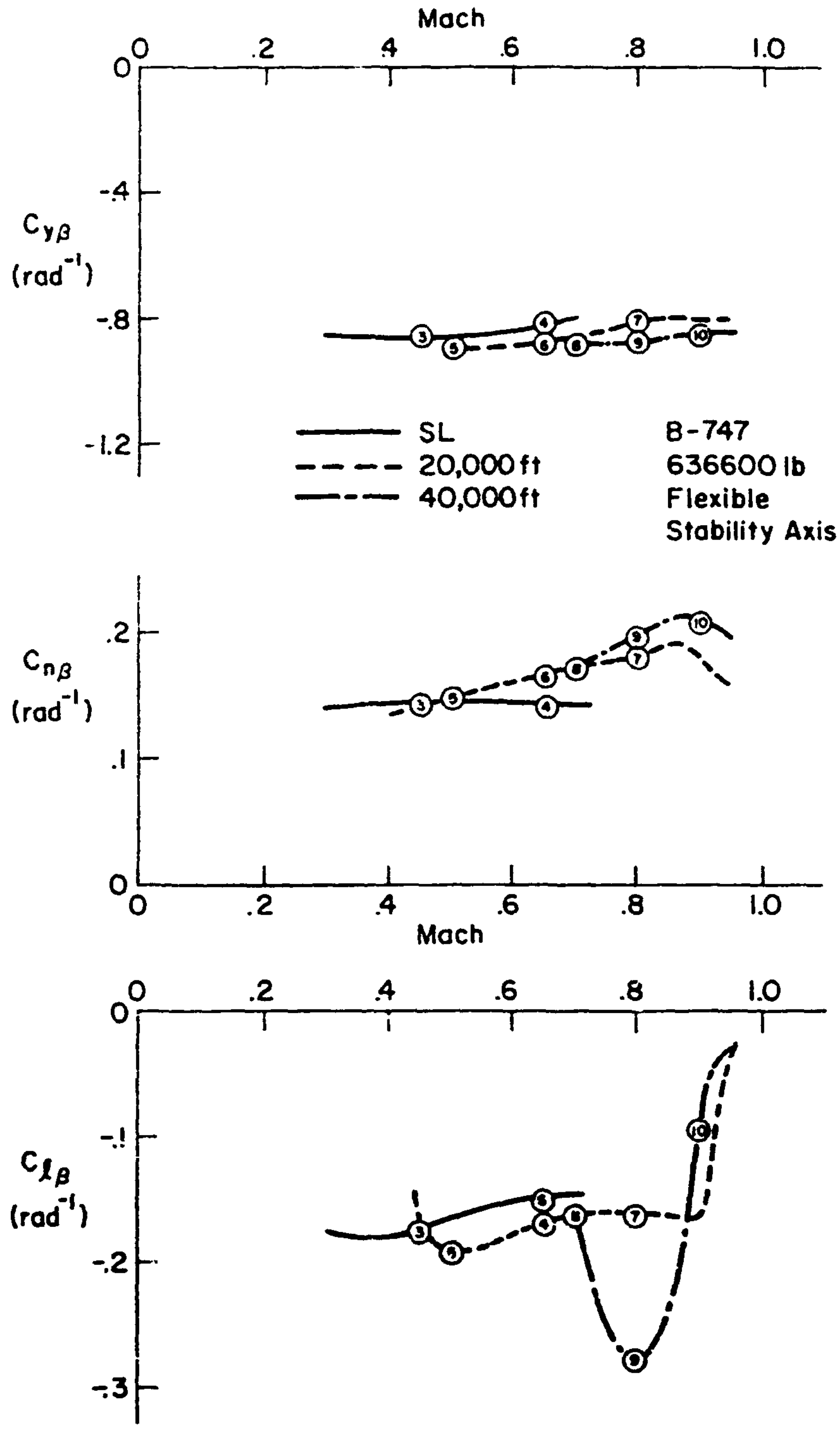
Mach
0
.2
.4
.6
.8
1.0
0
-.4
-.8
-1.2
-1.6
B-747
636600 lb
.25 c̄
Flexiable
C_{m_α}
(rad^{-1})
Mach
0
.2
.4
.6
.8
1.0
0
-4
-8
-12
-16
-20
-24
$C_{m_{\dot\alpha}}$
$C_{m_{\dot\alpha}}$, C_{m_q}
(rad^{-1})
SL
20,000 ft
40,000 ft
C_{m_q}

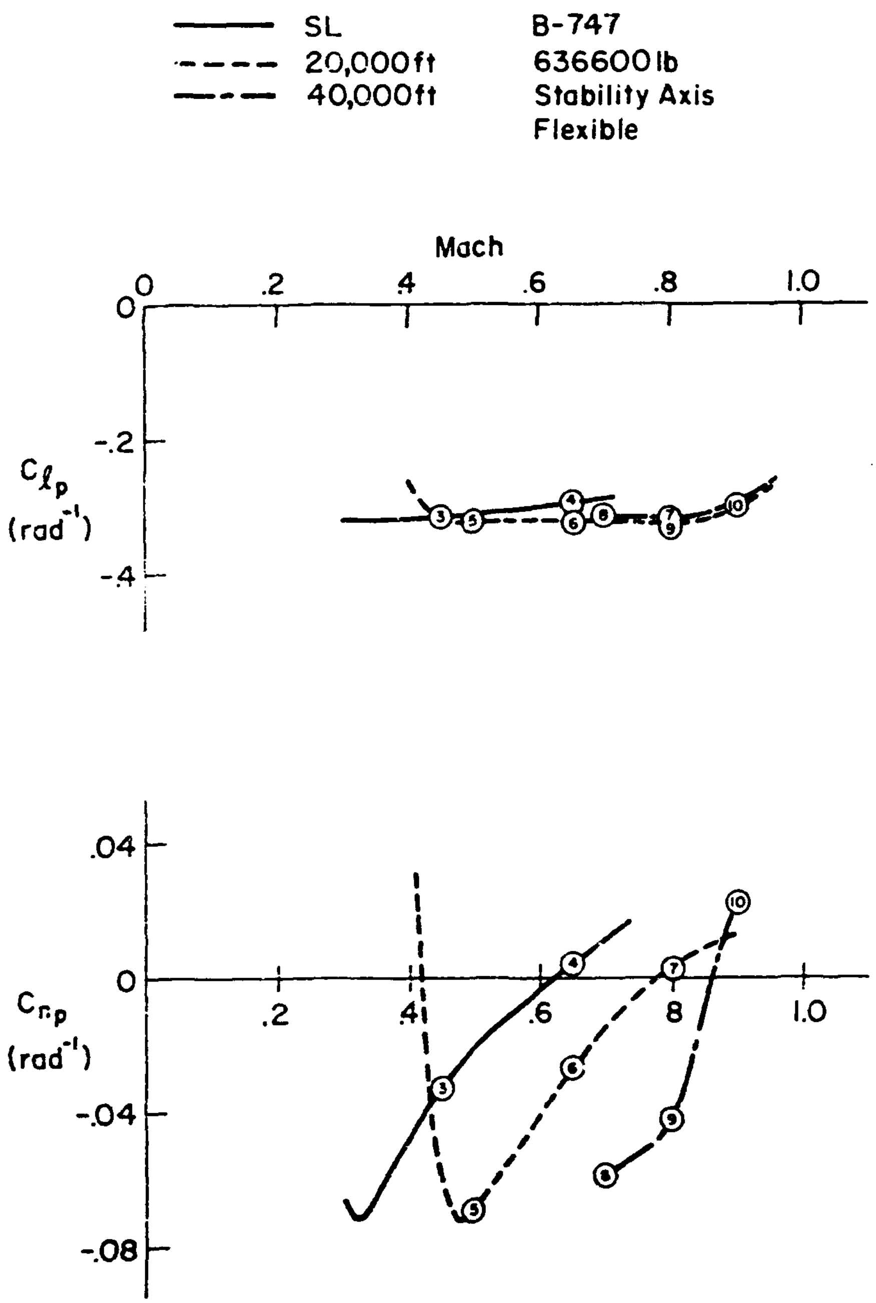


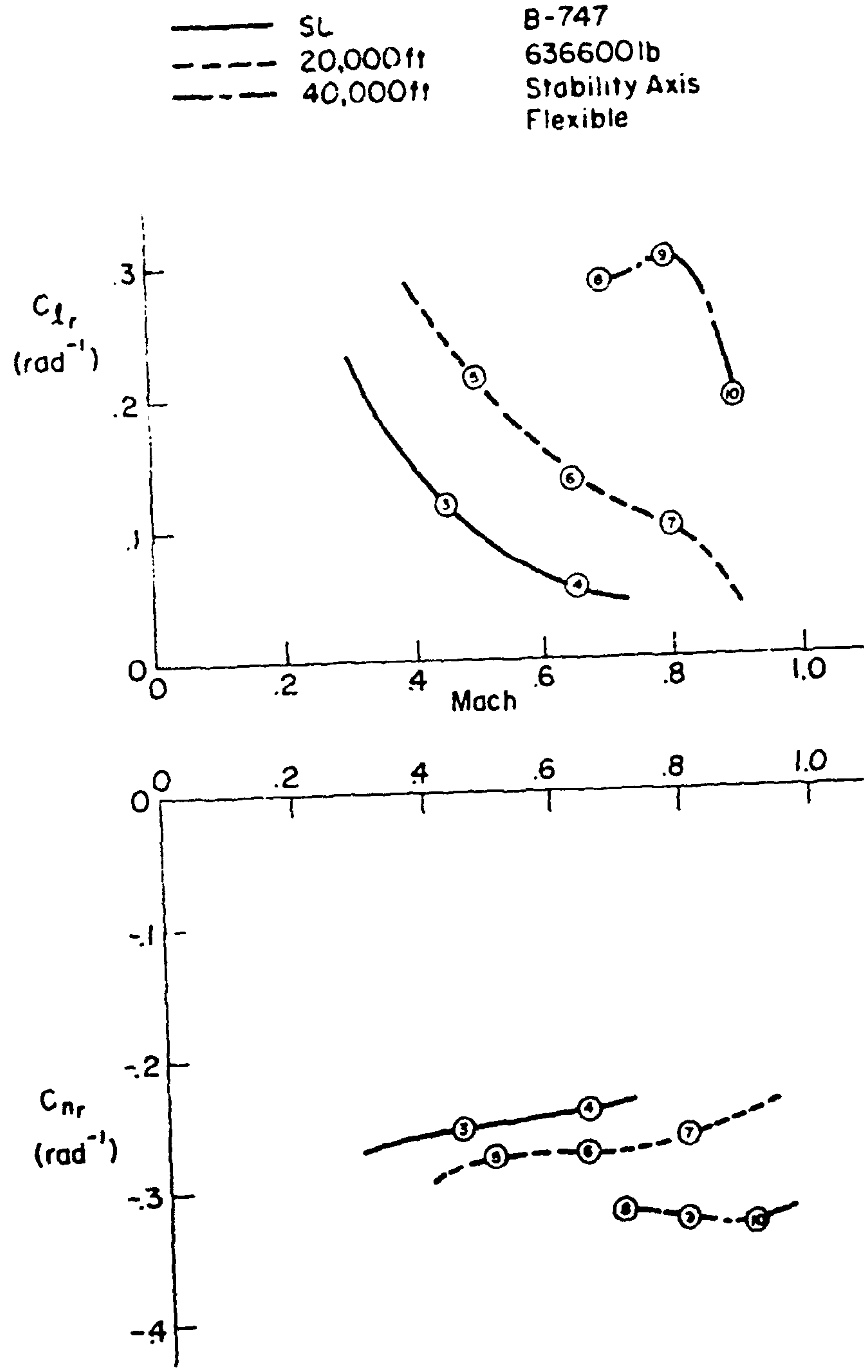
C_{L_M}
1
0
1
.2
.4
6
.8
1.0
Mach
SL
20,000ft
40,000ft
B-747
636600lb
.25 c̄
Flexible
C_{D_M}
.3
.2
.1
0
0
.2
.4
.6
.8
1.0
C_{m_M}
.4
.2
0
-.2
-.4



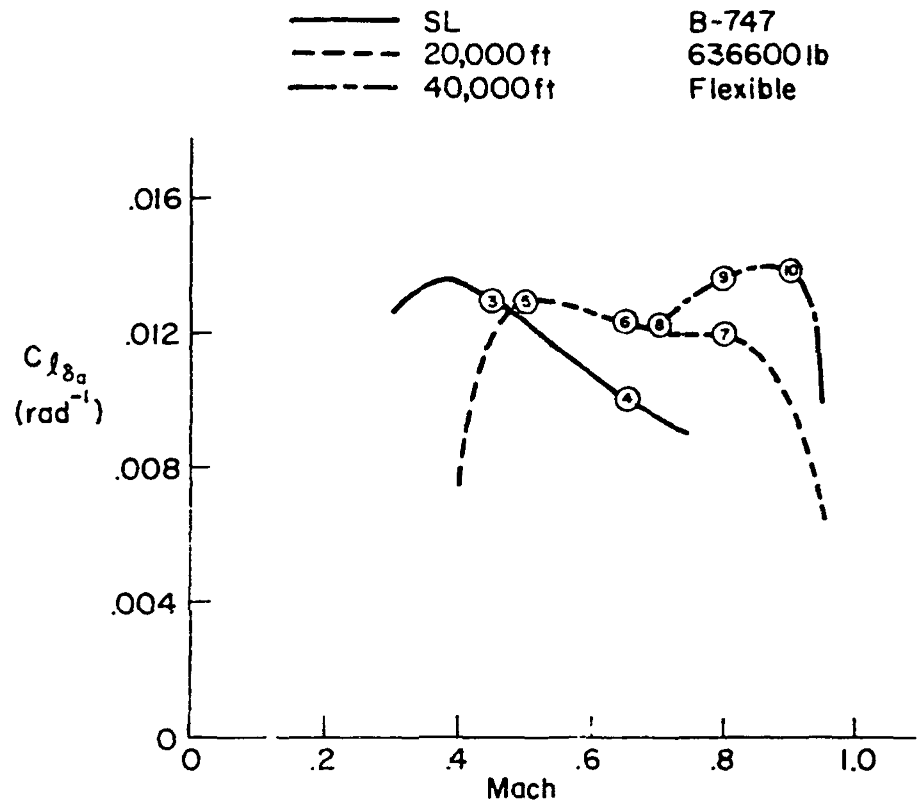
SL
20,000 ft
40,000 ft
B-747
$C_{L_{\delta_e}}$ (rad^{-1})
.4
.3
.2
.1
0
0
.2
.4
.6
.8
1.0
Mach
$C_{m_{\delta_e}}$ (rad^{-1})
-.4
-.8
-1.2
-1.6
3
4
5
6
7
8
9
10


Mach
0
.2
.4
.6
.8
1.0
0
-.4
-.8
-1.2
$C_{y\beta}$ (rad^{-1})
SL
20,000 ft
40,000 ft
B-747
636600 lb
Flexible
Stability Axis
.2
.1
0
$C_{n\beta}$ (rad^{-1})
Mach
-.1
-.2
-.3
$C_{\ell\beta}$ (rad^{-1})


SL
20,000 ft
40,000 ft
B-747
636600 lb
Stability Axis
Flexible
Mach
0
.2
.4
.6
.8
1.0
C_{ℓ_p}
(rad^{-1})
-.2
-.4
C_{n_p}
(rad^{-1})
.04
-.04
-.08

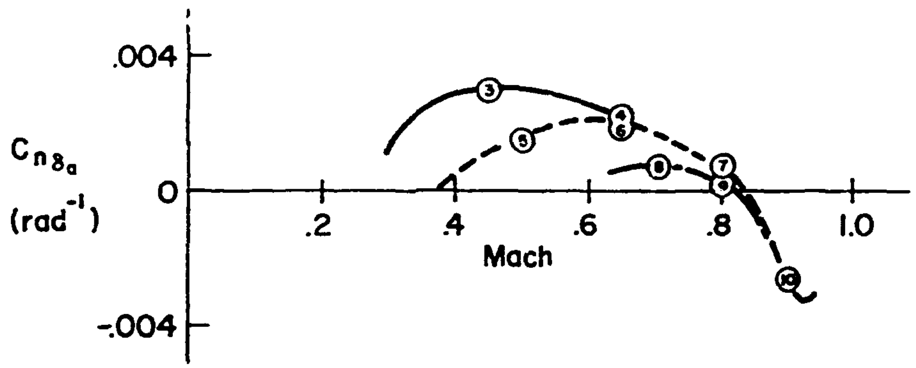


SL
20,000 ft
40,000 ft
B-747
636600 lb
Stability Axis
Flexible
C_{ℓ_r}
(rad^{-1})
.3
.2
.1
0
0
.2
.4
.6
.8
1.0
Mach
0
.2
.4
.6
.8
1.0
0
-.1
-.2
-.3
-.4
C_{n_r}
(rad^{-1})



Note:

- Because spoilers operate around a dead band their effect is neglected here
- δ_a is the total differential deflection of right and left inboard ailerons



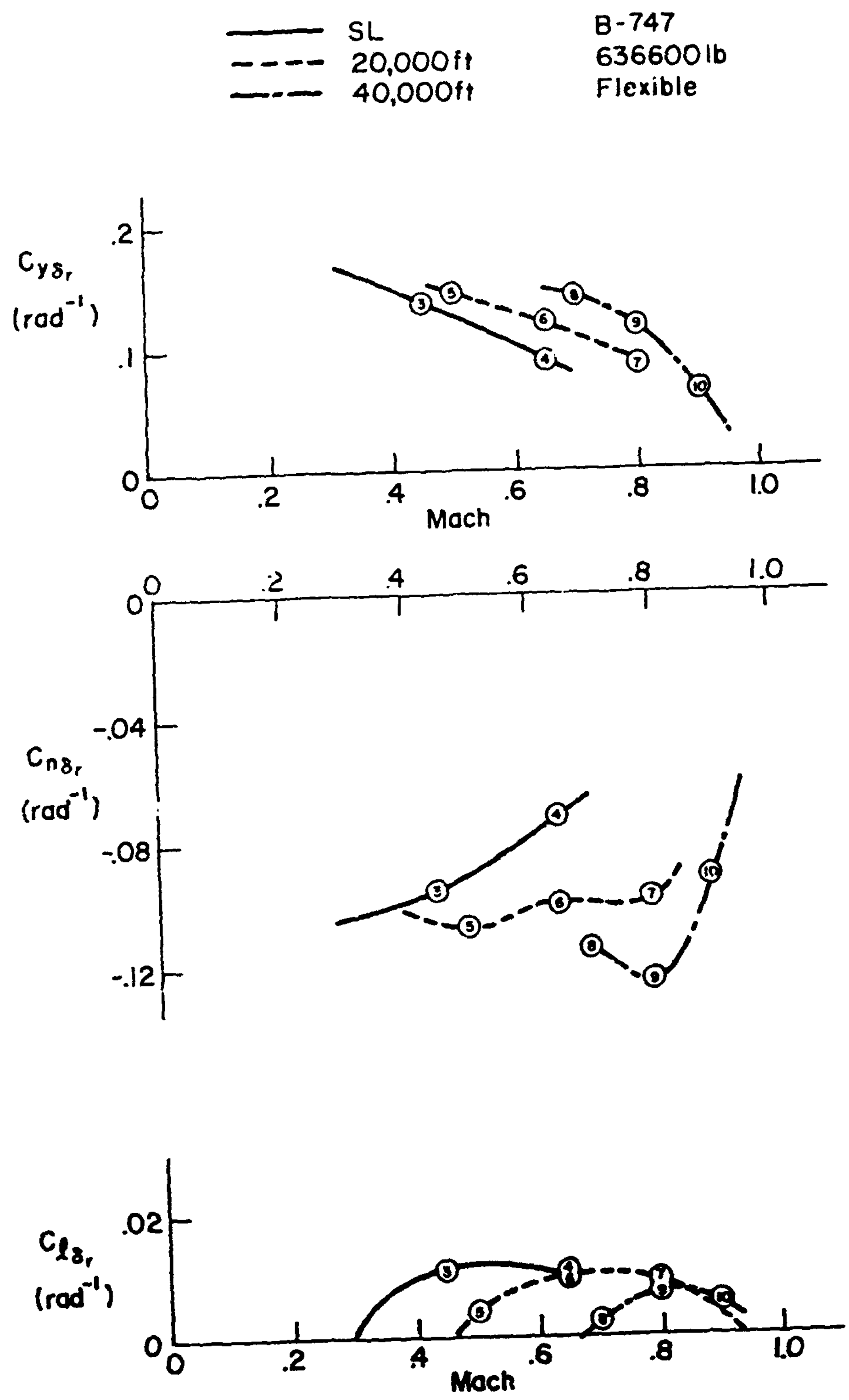

SL
20,000ft
40,000ft
B-747
636600lb
Flexible
$C_{y\delta_r}$
(rad^{-1})
.2
.1
0
0
.2
.4
.6
.8
1.0
Mach
$C_{n\delta_r}$
(rad^{-1})
-.04
-.08
-.12
$C_{\ell\delta_r}$
(rad^{-1})
.02

TABLE IX-3

B-747 DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

s = 5500 sq ft, b = 195.68 ft, $\bar{c}$ = 27.31 ft

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M(-)	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
VTO(FPS)	221.	278.	502.	726.	518.	674.	830.	678.	774.	871.
VTO(KTAS)	131.	165.	298.	430.	307.	399.	492.	402.	459.	515.
VTO(KCAS)	131.	165.	298.	430.	228.	299.	373.	210.	242.	278.
W(LBS)	564032.	564032.	636636.	636636.	636636.	636636.	636636.	636636.	636636.	636636.
C.G.(MGC)	.250	.250	.250	.250	.250	.250	.250	.250	.250	.250
IX (SLUG-FT SQ)	.142E+8	.142E+8	.182E+8	.182E+8	.182E+8	.182E+8	.182E+8	.182E+8	.182E+8	.182E+8
IY (SLUG-FT SQ)	.323E+8	.323E+8	.331E+8	.331E+8	.331E+8	.331E+8	.331E+8	.331E+8	.331E+8	.331E+8
IZ (SLUG-FT SQ)	.454E+8	.454E+8	.497E+8	.497E+8	.497E+8	.497E+8	.497E+8	.497E+8	.497E+8	.497E+8
IXZ(SLUG-FT SQ)	870050.	870050.	970056.	970056.	970056.	970056.	970056.	970056.	970056.	970056.
EPSILON(DEG)	-1.60	-1.60	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76
Q(PSF)	58.1	92.2	300.	626.	170.	288.	436.	135.	177.	224.
QC(PSF)	58.7	93.6	315.	695.	181.	320.	510.	153.	207.	273.
ALPHA(DEG)	8.50	5.70	3.10	0.	6.80	2.50	0.	7.30	4.60	2.40
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0
LZP(FT)	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
ITH(DEG)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
XI(DEG)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
LTH(FT)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

TABLE IX-4

B-747 LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
XU *	-.0209	-.0108	-.00499	-.00777	-.00247	-.00280	-.00643	.00187	-.00276	-.0200
ZU *	-.202	-.150	-.0807	-.126	-.0679	-.0832	-.0941	-.0696	-.0650	-.0424
MU *	.000117	.000181	.000146	-.000199	.000247	.885E-4	-.000222	.000259	.000193	.523E-4
XW	.122	.106	.0743	.0365	.0782	.0482	.0253	.0263	.0349	.0159
ZW	-.512	-.613	-.736	-.963	-.433	-.539	-.624	-.292	-.317	-.401
MW	-.00177	-.00193	-.00262	-.00239	-.00170	-.00190	-.00153	-.00101	-.00105	-.00190
ZWD	.0334	.0338	.0257	.0253	.0157	.0156	.0144	.00704	.00556	.00614
ZQ	-6.22	-7.58	-10.4	-12.8	-6.39	-8.09	-9.98	-4.32	-5.16	-6.71
MWD	-.000246	-.000240	-.000221	-.000228	-.000125	-.000155	-.000212	-.905E-4	-.000116	-.000160
MQ	-.357	-.437	-.699	-.925	-.421	-.535	-.659	-.284	-.339	-.401
XDE	.959	.971	1.18	0.	2.02	1.15	0.	1.93	1.44	.781
ZDE	-6.42	-9.73	-21.8	-32.4	-16.9	-26.4	-32.7	-15.1	-17.9	-18.6
MDE	-.378	-.574	-1.40	-2.07	-1.09	-1.69	-2.09	-.970	-1.16	-1.22
XDTH	.570E-4	.570E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4
ZDTH	-.249E-5	-.249E-5	-.220E-5	-.220E-5	-.220E-5	-.220E-5	-.220E-5	-.220E-5	-.220E-5	-.220E-5
MDTH	.310E-6	.310E-6	.302E-6	.302E-6	.302E-6	.302E-6	.302E-6	.302E-6	.302E-6	.302E-6

TABLE IX-5

B-747 ELEVATOR TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.550	.800	.700	.800	.900
DENOMINATOR										
Z(DET)1	.0417	.0228	.0319	.110	.0241	.0264	.323	.0636	.0489	.304
W(DET)1	.152	.127	.0753	.0363	.0823	.0553	.00984	.0781	.0673	.0311
Z(DET)2	.616	.629	.575	.637	.446	.473	.567	.357	.387	.351
W(DET)2	.771	.910	1.37	1.63	1.04	1.26	1.30	.879	.944	1.15
NUMERATORS										
N(U /DE)										
A(U)	.993	1.01	1.22	-1.15	2.05	1.17	-.873	1.95	1.45	.785
1/T(U)1	11.9	15.2	21.1	3.71	32.7	42.0	1.83	42.8	40.6	56.0
Z(U)1	.441	.390	.269	(-14.9)	.306	.335	(-25.5)	.705	.434	.783
W(U)1	.725	.857	.526		.469	.738		.323	.399	.578
N(W /DE)										
A(W)	-6.65	-10.1	-22.5	-33.3	-17.2	-26.8	-33.2	-15.2	-18.0	-18.7
1/T(W)1	12.9	16.4	32.3	46.6	33.2	43.0	52.7	43.2	50.1	56.9
Z(W)1	.0814	.0514	.0401	.0510	.0238	.0338	.0537	.00781	.0435	.260
W(W)1	.171	.133	.0728	.0728	.0666	.0635	0593	.0593	.0531	.0327
N(THE/DE)										
A(THE)	-.377	-.572	-1.40	-2.07	-1.09	-1.68	-2.07	-.968	-1.16	-1.21
1/T(THE)1	.0801	.0396	.0136	.0124	.0154	.0107	.0105	.00419	.0113	.0217
1/T(THE)2	.440	.574	.711	.952	.400	.511	.606	.272	.295	.373
N(HD /DE)										
A(HD)	6.72	10.1	22.5	33.3	17.3	26.8	33.2	15.3	18.0	18.8
1/T(HD)1	-.0118	-.00415	.00240	.00646	-.00302	.000539	.00456	-.0151	-.00166	.0161
1/T(HD)2	-2.17	-2.75	-4.21	-5.70	-3.35	-4.29	-5.15	-3.19	-3.64	-4.36
1/T(HD)3	2.71	3.39	5.31	7.43	3.97	5.07	6.13	3.59	4.08	4.82
N(AZP/DE)										
A(AZP)	25.7	39.1	97.7	144.	76.3	118.	145.	69.1	81.7	65.7
1/T(AZP)1	.0339	.0189	-.00577	0.	.00927	-.00645	0.	.00154	.00532	-.00198
1/T(AZP)2	-.0468	-.0233	.00914	.00645	-.0126	.00497	.00456	-.0147	-.00725	.0179
Z(AZP)1	.213	.197	.140	.127	.109	.103	.0984	.0831	.0771	.0943
W(AZP)1	1.24	1.55	2.27	3.15	1.73	2.23	2.69	1.61	1.81	2.15

TABLE IX-6

B-747 THRUST TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
DENOMINATOR										
Z(DET)1	.0417	.0228	.0319	.110	.0241	.0264	.323	.0636	.0489	.304
W(DET)1	.152	.127	.0753	.0368	.0823	.0653	.00984	.0781	.0673	.0311
Z(DET)2	.616	.629	.575	.637	.446	.473	.567	.357	.367	.351
W(DET)2	.771	.910	1.37	1.63	1.04	1.26	1.30	.879	.964	1.35
NUMERATORS										
N(U /DTH)										
A(U)	.571E-4	.570E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4
1/T(U)1	-.173	-.141	-.0823	-.0700	-.0943	-.0715	-.0713	-.114	-.0803	-.0502
Z(U)1	.592	.605	.540	.646	.323	.433	.6	.159	.251	.301
W(U)1	.784	.928	1.37	1.67	1.00	1.25	1.32	.740	.908	1.29
N(W /DTH)										
A(W)	-.287E-5	-.277E-5	-.236E-5	-.227E-5	-.234E-5	-.227E-5	-.224E-5	-.227E-5	-.225E-5	-.223E-5
1/T(W)1	-19.4	-27.6	-62.6	-93.8	-65.1	-87.5	-109.	-88.1	-102.	-116.
Z(W)1	-.0347	.0126	.0785	-.355	.286	.0642	-.360	.360	.320	.0817
W(W)1	.189	.139	.0728	.0775	.0627	.0637	.0621	.0551	.0524	.0400
N(THE/DTH)										
A(THE)	.312E-6	.312E-6	.303E-6	.303E-6	.303E-6	.303E-6	.303E-6	.303E-6	.303E-6	.303E-6
1/T(THE)1	(.876)	.197	.0858	.0326	.115	.0808	.0125	.110	.0932	.0484
1/T(THE)2	(.340)	.504	.721	.955	.383	.500	.603	.233	.270	.379
N(HD /DTH)										
A(HD)	.113E-4	.842E-5	.508E-5	.227E-5	.830E-5	.448E-5	.224E-5	.866E-5	.629E-5	.434E-5
1/T(HD)1	.118	.102	.0686	.0243	.0739	.0601	.00572	.0652	.0626	.0372
Z(HD)1	.433	.330	.170	.139	.176	.158	.158	.161	.153	.127
W(HD)1	1.97	2.74	4.98	10.[illegible]	3.06	5.18	8.60	2.75	3.58	5.13
N(AZP/DTH)										
A(AZP)	-.297E-4	-.296E-4	-.284E-4	-.283E-4	-.284E-4	-.283E-4	-.283E-4	-.283E-4	-.283E-4	-.283E-4
1/T(AZP)1	-.0276	-.0137	-.00376	0.	-.00810	-.00231	0.	-.00689	-.00372	-.00169
1/T(AZP)2	.188	.122	.0791	.0243	.0884	.0641	.00973	.0761	.0692	.0401
Z(AZP)1	.362	.302	.203	.195	.164	.160	.161	.135	.128	.124
W(AZP)1	1.15	1.42	2.08	2.84	1.58	2.03	2.42	1.46	1.69	1.98

TABLE IX-7

B-747 LONGITUDINAL HANDLING QUALITIES PARAMETERS

Bare Airframe

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
STICK FIXED										
D(G)/D(U) (DEG/KT)	.0349	.0123	-.00726	-.0194	.00900	-.00166	-.0137	.0452	.00464	-.0496
NZA (G/RAD)	3.27	5.00	10.8	20.8	6.50	10.7	15.4	5.76	7.22	10.1
DE/G (DEG/G)	25.9	15.7	6.80	3.43	8.45	4.95	2.98	7.75	6.25	8.45
CAP (RAD/SEC/SEC/G)	.170	.157	.166	.124	.160	.145	.108	.131	.127	.179
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	--	--	--	--	--
1/C(1/10)	2.13	2.21	1.92	2.26	1.36	1.46	1.88	1.04	1.14	1.02

TABLE IX-8

B-747 LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
YV	-.0890	-.0997	-.143	-.197	-.0822	-.104	-.120	-.0488	-.0558	-.0606
YB	-19.7	-27.8	-71.7	-143.	-42.6	-70.4	-99.4	-33.1	-43.2	-52.8
LB'	-1.33	-1.63	-3.19	-5.45	-2.05	-2.96	-4.12	-1.45	-3.05	-1.32
NB'	.168	.247	.810	1.82	.419	.923	1.62	.404	.598	.971
LP'	-.975	-1.10	-1.12	-1.47	-.652	-.804	-.974	-.404	-.465	-.459
NP'	-.166	-.125	-.0706	-.0214	-.0701	-.0531	-.0157	-.0366	-.0318	.00284
LR'	.327	.198	.379	.256	.376	.317	.292	.312	.388	.280
NR'	-.217	-.229	-.246	-.344	-.140	-.193	-.232	-.0963	-.115	-.141
Y*CA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
L'CA	.227	.318	.229	.372	.128	.210	.310	.0964	.143	.186
N'CA	.0264	.0300	.0285	.0371	.0177	.0199	.0127	.00875	.00775	-.00611
Y*CR	.0148	.0182	.0226	.0213	.0131	.0142	.0124	.00777	.00729	.00464
L'CR	.0636	.110	.254	.318	.148	.211	.183	.115	.153	.100
N'CR	-.181	-.233	-.614	-.970	-.351	-.616	-.922	-.331	-.475	-.442

TABLE IX-9

B-747 AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.158	.249	.450	.650	.500	.650	.800	.700	.800	.900
DENOMINATOR										
1/T(DET)1	.0427	.0465	.0194	.0203	.00903	.0108	.0103	-.00234	.00740	-.00777
1/T(DET)2	1.11	1.23	1.23	1.56	.745	.913	1.06	.462	.562	.478
Z(DET)1	.0878	.107	.126	.153	.0693	.0623	.0981	.0568	.0349	.0929
W(DET)1	.735	.746	1.06	1.40	.863	1.07	1.31	.788	.947	1.02
NUMERATORS										
N(B /DA)										
A(B)	.00740	.00171	-.0161	-.0371	-.00243	-.0107	-.0127	.00358	.00373	.0139
1/T(B)1	.154	.176	.448	-.168	.174	.230	.333	.0981	.0995	.103
1/T(B)2	7.10	25.9	-.605	.981	-3.62	-.910	-.694	1.61	2.17	.628
N(P /DA)										
A(P)	.227	.318	.229	.372	.128	.210	.310	.0964	.143	.186
1/T(P)1	-.0199	-.0108	-.00335	0.	-.00722	-.00205	0.	-.00601	-.00334	-.00154
Z(P)1	.308	.274	.197	.181	.166	.149	.135	.122	.111	.100
W(P)1	.591	.653	1.12	1.56	.846	1.11	1.35	.734	.677	.967
N(R /DA)										
A(R)	.0264	.0300	.0285	.0371	.0177	.0199	.0127	.00875	.00775	-.00611
1/T(R)1	.499	.593	.849	1.68	.442	.718	1.46	.330	.435	-1.22
Z(R)1	-.482	-.395	-.0874	-.142	-.128	-.201	-.367	-.193	-.217	.593
W(R)1	.895	.507	.855	.791	.842	.920	1.08	.919	1.16	.925
N(PHI/DA)										
A(PHI)	.231	.321	.230	.372	.130	.211	.310	.0975	.143	.186
Z(PHI)1	.284	.264	.196	.181	.162	.148	[illegible]	[illegible]	.109	[illegible]
W(PHI)1	.586	.680	1.12	1.56	.844	1.11	[illegible]	[illegible]	.878	.968
N(AYP/DA)										
A(AYP)	4.54	5.76	4.74	6.91	2.80	3.82	4.19	1.72	2.10	1.34
1/T(AYP)1	.257	.279	-.143	-.0950	-.151	-.137	-.126	-.134	-.135	-.165
1/T(AYP)2	-.331	-.313	.406	.056	.216	.264	[illegible]	.141	.149	[illegible]
Z(AYP)1	.0469	.121	.149	.146	.109	.0983	[illegible]	.0731	.0529	.0405
W(AYP)1	.643	.705	1.07	1.42	.847	1.07	[illegible]	.762	.407	1.11

TABLE IX-10

B-747 RUDDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.158	.249	.450	.650	.500	.650	.800	.700	.800	.900
DENOMINATOR										
1/T(DET)1	.0427	.0465	.0194	.0203	.00463	.0108	.0103	-.00234	.00730	-.00777
1/T(DET)2	1.11	1.23	1.23	1.56	.745	.913	1.06	.462	.562	.476
Z(DET)1	.0878	.107	.126	.153	.0693	.0623	.0981	.0568	.0349	.0929
W(DET)1	.735	.746	1.06	1.40	.863	1.07	1.31	.789	.947	1.02
NUMERATORS										
N(B /DR)										
A(B)	.0148	.0182	.0226	.0213	.0131	.0142	.0124	.00777	.00729	.00464
1/T(B)1	-.0503	-.0192	-.0182	-.00420	-.0359	-.0162	-.00957	-.0366	-.0324	-.0208
1/T(B)2	1.05	1.17	1.16	1.50	.665	.830	.995	.411	.478	.471
1/T(B)3	11.0	13.6	28.0	45.8	31.0	44.0	74.4	44.3	66.8	96.3
N(P /DR)										
A(P)	.0636	.110	.254	.318	.148	.211	.183	.115	.153	[illegible]
1/T(P)1	-.0209	-.0113	-.00340	0.	-.00728	-.00206	0.	-.00601	-.00532	-.00151
1/T(P)2	1.42	1.64	2.28	3.58	1.83	2.41	3.75	1.57	2.45	[illegible]
1/T(P)3	-2.18	-1.99	-3.09	-4.18	-2.77	-3.24	-5.15	-2.41	-3.63	-2.63
N(R /DR)										
A(R)	-.151	-.233	-.614	-.970	-.391	-.616	-.922	-.331	-.475	-.442
1/T(R)1	1.05	1.17	1.16	1.58	.621	.865	1.11	.393	.448	.524
Z(R)1	.0750	.0895	.130	.0796	.144	.0522	-.0466	.0769	.0245	-.0263
W(R)1	.416	.384	.397	.370	.434	.382	.364	.397	.488	.278
N(PHI/DR)										
A(PHI)	.0410	.0867	.221	.318	.101	.185	.183	.0727	.115	.0915
1/T(PHI)1	1.48	1.69	2.35	3.58	2.01	2.50	3.75	1.79	2.49	1.43
1/T(PHI)2	-3.31	-2.48	-3.47	-4.18	-3.74	-3.58	-5.15	-3.40	-4.44	-3.30
N(AYP/DR)										
A(AYP)	-9.12	-13.9	-38.9	-64.7	-25.3	-41.3	-67.1	-22.1	-33.7	-33.0
1/T(AYP)1	-.0646	-.0386	-.0268	-.0103	-.0373	-.0210	-.0126	-.0330	-.0284	[illegible]
1/T(AYP)2	.958	1.07	.973	1.32	.491	.669	.648	.312	.334	[illegible]
Z(AYP)1	.247	.208	.191	.137	.193	.147	.116	.136	.135	.0797
W(AYP)1	.668	.740	1.11	1.45	.984	1.10	1.22	.820	1.05	.973

TABLE IX-11

B-747 AILERON TRANSFER FUNCTION FACTORS

SAS On

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
DENOMINATOR										
1/T(DET)1	.0770	.198	.0148	.0160	.00688	.00843	.00801	-.00185	.00514	-.00687
1/T(DET)2	.471	.658	.804	1.63	.495	.696	1.28	.386	.447	2.83
1/T(DET)3	1.20	1.53	(.524)	(.795)	1.09	1.67	(.685)	.808	1.10	(.973)
1/T(DET)4	3.19	2.50	(.900)	(.791)	2.91	1.90	(.748)	3.07	2.68	(.540)
1/T(DET)5	9.26	9.03	(.978)	(.692)	(.267)	(.477)	(.729)	(.234)	(.265)	(.437)
1/T(DET)6	10.7	10.9	(1.94)	(2.28)	(.794)	(.908)	(2.10)	(.716)	(.828)	(.961)
Z(DET)1	.472	.849								
W(DET)1	.576	.287								
NUMERATORS										
N(B /DA)										
A(B)	.00740	.00171	-.0161	-.0371	-.00243	-.0107	-.0127	.00358	.00371	.0139
1/T(B)1	11..	13.0	.0905	.101	.0706	.0633	.0535	.0479	.0411	.0413
1/T(B)2	13.7	39.4	.841	-.381	.465	.708	-1.17	.371	.464	3.27
Z(B)1	.790	.150	(-1.21)	(1.78)	(4.90)	(-1.57)	(1.58)	.783	.754	.906
W(B)1	.289	.444	(3.97)	(3.25)	(-5.32)	(4.03)	(3.17)	3.47	3.00	.806
Z(B)2	.901	.649								
W(B)2	3.69	2.88								
N(P /DA)										
A(P)	.227	.318	.229	.372	.128	.210	.310	.0044	.143	[illegible]
1/T(P)1	-.0198	-.0107	-.00335	0.	-.00721	-.00204	0.	-.00600	-.00331	-.00154
1/T(P)2	.863	1.48	.613	.466	.619	.611	.621	.612	.706	.525
1/T(P)3	3.04	2.43	1.80	1.28	2.86	2.07	.907	3.04	2.67	2.84
1/T(P)4	9.99	9.99	(.837)	(.610)	(.577)	(.740)	(.690)	(.456)	(.581)	(.475)
1/T(P)5	10.0	10.0	(1.24)	(2.35)	(.741)	(1.15)	(2.09)	(.626)	(.743)	(.931)
Z(P)1	.594	.616								
W(P)1	.426	.402								
N(R /DA)										
A(R)	.0264	.0300	.0285	.0371	.0177	.0199	.0127	.00875	.00775	-.00611
1/T(R)1	3.96	13.6	.368	.359	.368	.368	.368	.330	.368	.368
1/T(R)2	6.22	(.573)	.849	1.08	.442	.718	1.46	.369	.435	-1.22
1/T(R)3	12.7	(.351)	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68
Z(R)1	.773	.834	-.0874	-.142	-.128	-.201	-.347	-.153	-.217	.993
W(R)1	.410	1.49	.855	.791	.842	.920	1.08	.919	1.16	.925
Z(R)2	.0977	.952								
W(R)2	1.02	4.22								

TABLE IX-11 (Concluded)

N(PHI/DA)										
A(PHI)	.231	.321	.230	.372	.130	.211	.310	.0975	.143	.186
1/T(PHI)1	.838	1.46	.616	.468	.615	.612	.621	.606	.702	.526
1/T(PHI)2	3.06	2.45	1.83	1.28	2.87	2.09	.907	3.05	2.68	2.84
1/T(PHI)3	9.59	9.59	(.834)	(.610)	(.563)	(.736)	(.690)	(.445)	(.574)	(.474)
1/T(PHI)4	10.4	10.4	(1.22)	(2.35)	(.739)	(1.14)	(2.09)	(.629)	(.744)	(.922)
Z(PHI)1	.585	.620								
W(PHI)1	.428	.402								
N(AYP/DA)										
A(AYP)	4.54	5.76	4.74	6.91	2.80	3.82	4.19	1.72	2.10	1.34
1/T(AYP)1	-.249	-.175	.147	.149	.118	.103	.0823	.0835	.0700	.0698
1/T(AYP)2	3.35	2.87	-.212	-.151	-.217	-.217	-.226	-.202	-.227	-.273
1/T(AYP)3	7.80	7.16	.821	(.464)	.495	.694	(.324)	.440	.510	.699
1/T(AYP)4	11.7	12.2	2.94	(1.40)	3.30	2.94	(1.26)	3.32	3.08	2.51
Z(AYP)1	.794	.483	.425	.949	.348	.391	.932	.336	.382	.474
W(AYP)1	.360	.[illegible]79	1.09	1.96	.870	1.11	1.78	.775	.942	1.20
Z(AYP)2	.502	.857								
W(AYP)2	.723	1.02								

TABLE IX-12

B-747 RUDDER TRANSFER FUNCTION FACTORS

SAS On

(*Body Axis System*)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
DENOMINATOR										
1/T(DET)1	.0770	.198	.0148	.0160	.00688	.00843	.00901	-.00185	.00514	-.00687
1/T(DET)2	.471	.858	.804	1.63	.495	.696	1.28	.386	.447	2.83
1/T(DET)3	1.20	1.93	(.524)	(.799)	1.09	1.67	(.685)	.808	1.10	(.913)
1/T(DET)4	3.10	2.50	(.900)	(.791)	2.91	1.90	(.748)	3.07	2.[illegible]	(.540)
1/T(DET)5	9.26	9.03	(.978)	(.692)	(.267)	(.477)	(.729)	(.234)	(.255)	(.432)
1/T(DET)6	10.7	10.9	(1.94)	(2.28)	(.794)	(.908)	(2.10)	(.716)	(.838)	(.961)
Z(DET)1	.472	.849								
W(DET)1	.576	.207								
NUMERATORS										
N(B /DR)										
A(B)	.0148	.0182	.0226	.0213	.0131	.0142	.0124	.00777	.00729	.00464
1/T(B)1	-.0503	-.0192	-.0182	-.00420	-.0359	-.0162	-.00957	-.0366	-.0324	-.0298
1/T(B)2	.368	.368	.368	.368	.368	.368	.368	.368	.368	.368
1/T(B)3	1.05	1.17	1.16	1.50	.665	.830	.995	.411	.478	.471
1/T(B)4	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68
1/T(B)5	9.94	9.97	28.0	45.8	31.0	44.0	74.4	44.3	66.8	96.3
1/T(B)6	10.1	10.0								
1/T(B)7	11.0	13.6								
N(P /DR)										
A(P)	.0636	.110	.254	.318	.148	.211	.183	.115	.153	.190
1/T(P)1	-.0209	-.0113	-.00340	0.	-.00728	-.00206	0.	-.00601	-.00332	-.00153
1/T(P)2	.368	.360	.368	.368	.368	.368	.368	.368	.360	.368
1/T(P)3	1.42	1.64	2.28	3.58	1.83	2.41	3.68	1.57	2.45	1.74
1/T(P)4	-2.18	-1.99	-1.09	3.68	-2.77	-3.24	3.75	-2.41	-3.63	-2.83
1/T(P)5	3.68	3.68	3.68	-4.18	3.61	3.68	-5.15	3.68	3.68	3.68
Z(P)1	1.00	(9.98)								
W(P)1	10.0	(10.0)								
N(R /DR)										
A(R)	-.151	-.233	-.614	-.970	-.391	-.614	-.922	-.331	-.479	-.442
1/T(R)1	.368	.368	.368	.368	.368	.368	.368	.368	.368	.368
1/T(R)2	1.09	1.17	1.16	1.58	.621	.865	1.11	.393	.457	.524
1/T(R)3	3.68	3.68	3.68	3.66	3.68	3.65	3.68	3.68	3.68	3.68
1/T(R)4	9.99	9.98	(.130)	(.0796)	(.144)	(.0522)	(-.0468)	(.0789)	(.0245)	(-.0283)
1/T(R)5	10.0	10.0	(.397)	(.370)	(.434)	(.382)	(.364)	(.397)	(.488)	(.278)
Z(R)1	.0790	.0895								
W(R)1	.416	.284								

TABLE IX-12 (Concluded)

N(PHI/DR)										
A(PHI)	.0410	.0867	.221	.318	.191	.185	.183	.0727	.115	.0815
1/T(PHI)1	.368	.368	.268	.368	.368	.368	.368	.368	.368	.358
1/T(PHI)2	1.48	1.69	2.35	3.58	2.01	2.50	3.66	1.79	2.69	1.83
1/T(PHI)3	-3.31	-2.48	-3.47	3.68	3.68	-3.58	3.75	-3.40	3.68	-3.40
1/T(PHI)4	3.68	3.68	3.68	-4.18	-3.74	3.68	-5.15	3.68	-4.44	3.68
1/T(PHI)5	0.00	(1.00)								
1/T(PHI)6	10.0	(10.0)								
N(AYP/DR)										
A(AYP)	-9.12	-13.9	-38.9	-64.7	-25.3	-41.3	-67.1	-22.1	-33.7	-33.0
1/T(AYP)1	-.0646	-.0386	-.0268	-.0103	-.0373	-.0210	-.0125	-.0320	-.0244	-.0202
1/T(AYP)2	.368	.368	.368	.368	.368	.368	.368	.312	.334	.359
1/T(AYP)3	.558	1.07	.973	1.32	.491	.669	.848	.368	.366	.427
1/T(AYP)4	3.68	3.68	3.68	3.68	3.68	3.68	3.66	3.68	3.68	3.68
Z(AYP)1	.247	.208	.191	.137	.193	.147	.118	.136	.135	.0797
W(AYP)1	.668	.740	1.11	1.45	.904	1.10	1.22	.860	1.05	.873
Z(AYP)2	1.00	1.00								
W(AYP)2	10.0	10.0								

TABLE IX-13

B-747 LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
DR PERIOD (SEC)	8.59	8.47	5.98	4.53	7.30	5.87	4.83	7.99	6.64	6.19
1/C(1/2)	.799	.978	1.16	1.41	.630	.749	.894	.516	.317	.846
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	296.	--	97.2
P(1)	.178	.235	.211	.304	.162	.241	.302	.156	.188	.363
P(2)	.0285	.0867	.171	.253	.134	.215	.287	.153	.175	.359
P(3)	.111	.148	.182	.268	.155	.233	.299	.187	.221	.381
P(2)/P(1)	.160	.369	.811	.832	.832	.891	.949	.979	.935	.990
P(OSC)/P(AV)	.671	.377	.0691	.0618	.0019	.0494	.0238	.0569	.0755	.0174
W(PHI)/W(D)	.797	.871	1.05	1.11	.978	1.03	1.03	.933	.927	.950
DEL-B-MAX	.161	.136	.00830	.0178	.0219	.00936	.00425	.0301	.0234	.0316
PHI TO BETA, PHASE	-304.	-306.	43.0	37.0	-322.	35.4	32.5	-331.	-332.	[illegible]
PHI TO BETA	1.54	1.69	2.07	2.07	2.26	2.12	2.03	2.09	3.07	1.19
PHI TO VE	.399	.349	.236	.153	.343	.247	.192	.355	.456	.156

B-747 DATA SOURCES

Hanke, C. Rodney and Donald R. Nordwall, The Simulation of a Large Jet Transport Aircraft, Boeing Rept. No. D6-30643, Vols. I and II, Sept. 1970.

SECTION X

C-5A

C-5A BACKGROUND

The C-5A is a very large military logistics transport powered by four turbofan engines. Longitudinal control consists of elevators in four sections with an all-movable stabilizer for trim, roll control employs ailerons and spoilers, and yaw control a conventional rudder. All control surfaces are irreversible.

A bobweight is used in the longitudinal feel system. The effective bobweight position is assumed to be at the pilot.

The C-5A employs stability augmentation about all axes. A description of the SAS is not included here.

C-5A

Nominal Configuration

220,000 lb Cargo

TOGW less 40% Fuel

$W = 654{,}362$ lb

c.g. at 0.30 $\bar{c}$, W.L. 265

$$\left.\begin{aligned} I_x &= 27.8\times10^6 \text{ slug-ft}^2 \\ I_y &= 31.8\times10^6 \text{ slug-ft}^2 \\ I_z &= 56.2\times10^6 \text{ slug-ft}^2 \\ I_{xz} &= 2.46\times10^6 \text{ slug-ft}^2 \end{aligned}\right\}\text{ Body Axis}$$

Power Approach Configuration

220,000 lb Cargo

TOGW less 80% Fuel

30° Flaps

Gear Down

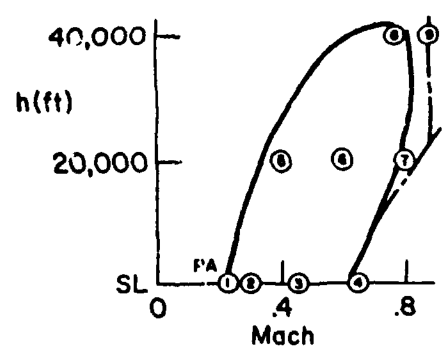
$1.4\ V_s$

$W = 580{,}723$ lb

c.g. at 0.30 $\bar{c}$, W.L. 265

$$\left.\begin{aligned} I_x &= 19.1\times10^6 \text{ slug-ft}^2 \\ I_y &= 31.3\times10^6 \text{ slug-ft}^2 \\ I_z &= 47.0\times10^6 \text{ slug-ft}^2 \\ I_{xz} &= 2.5\times10^6 \text{ slug-ft}^2 \end{aligned}\right\}\text{ Body Axis}$$

Flight Envelope



——— Level Flight Envelope (Nominal Configuration)

— - — Speed Restrictions

ⓝ Transfer Function Case n

Figure X-1. C-5A Flight Conditions

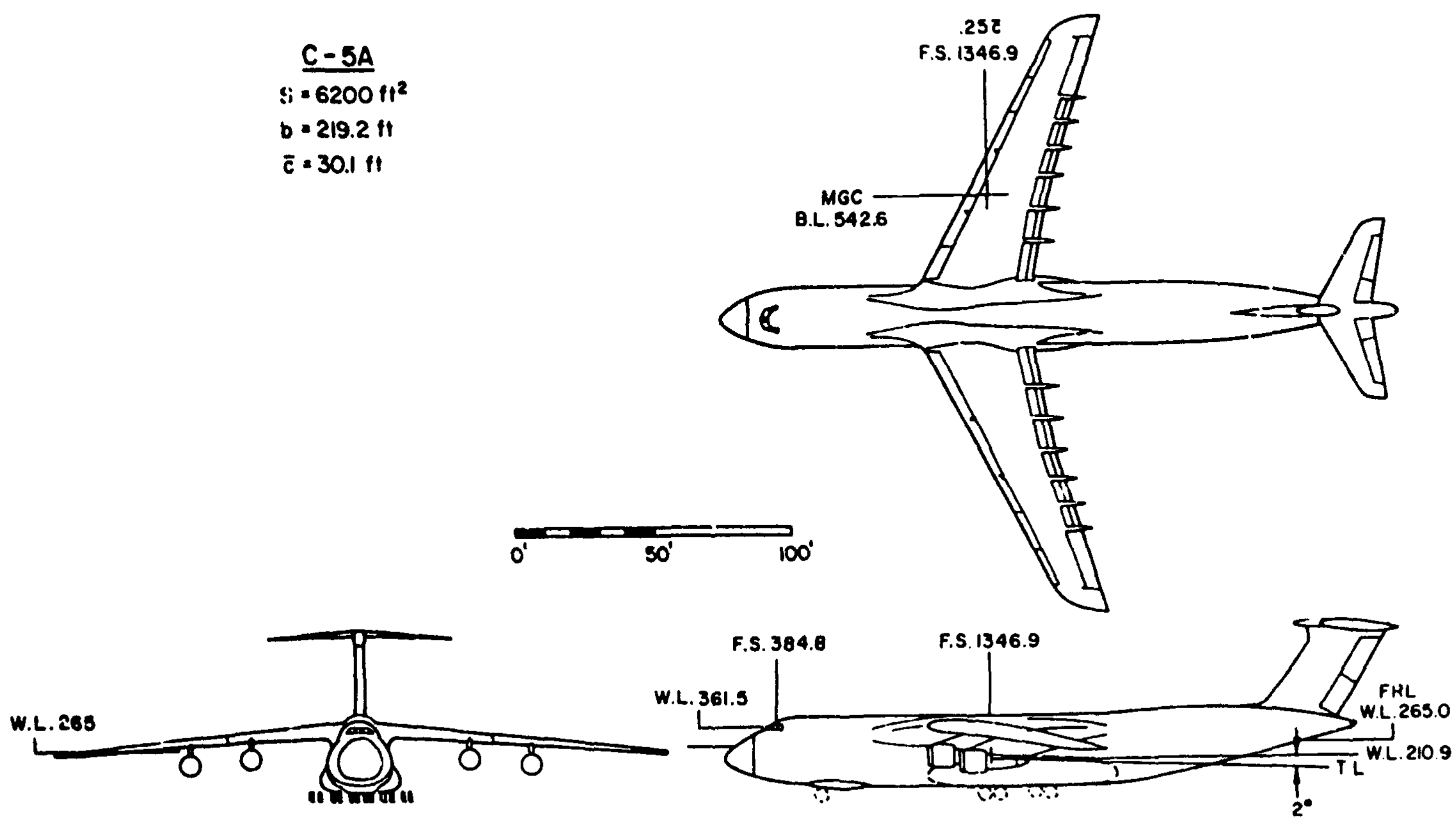
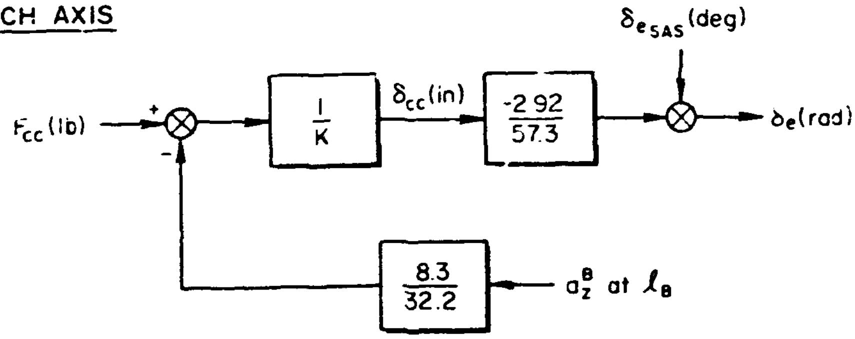
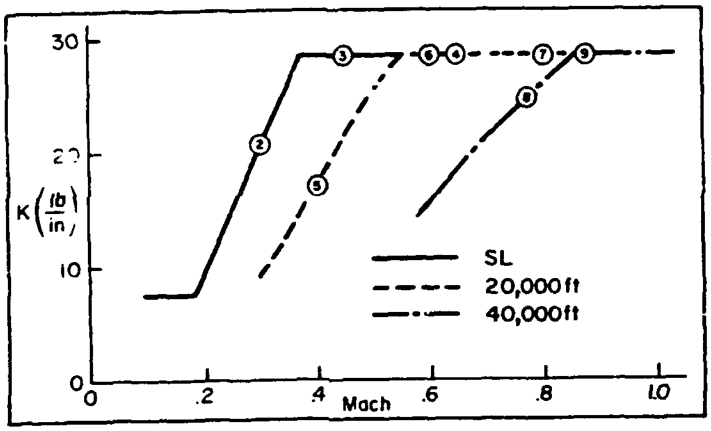


Figure X-2. C-5A General Arrangement

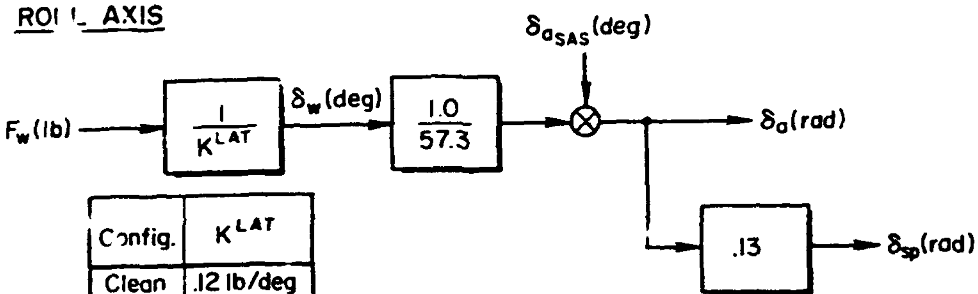
C-5A

PITCH AXIS





ROLL AXIS



Config.	K^{LAT}
Clean	.12 lb/deg
PA	.155 lb/deg

YAW AXIS

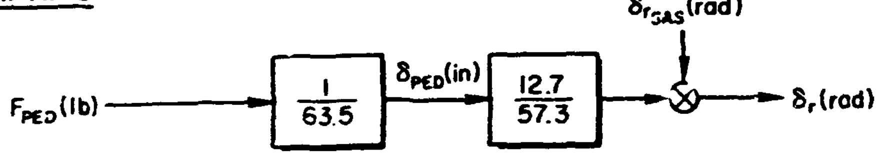


Figure X-3. C-5A Control System

TABLE X-1

C-5A

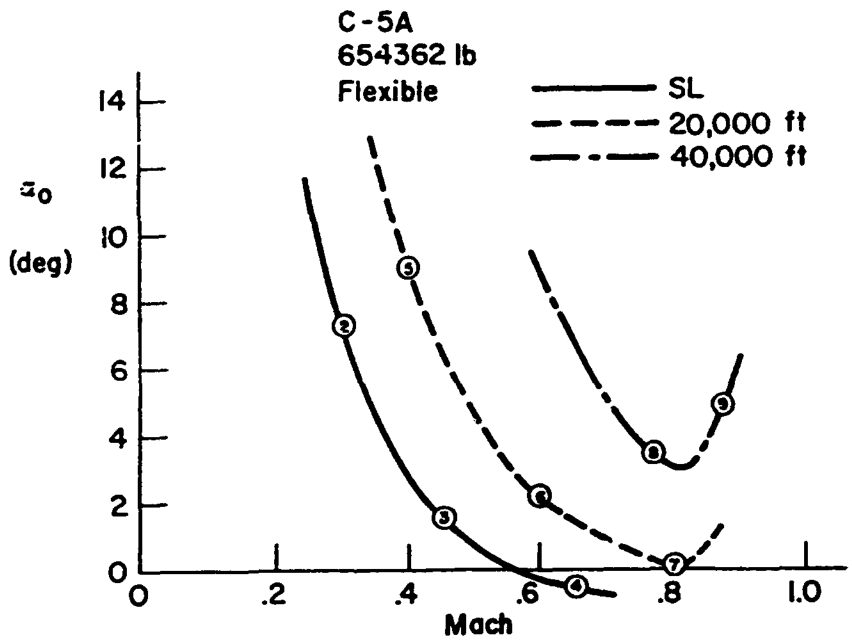
Power Approach Non-Dimensional Derivatives

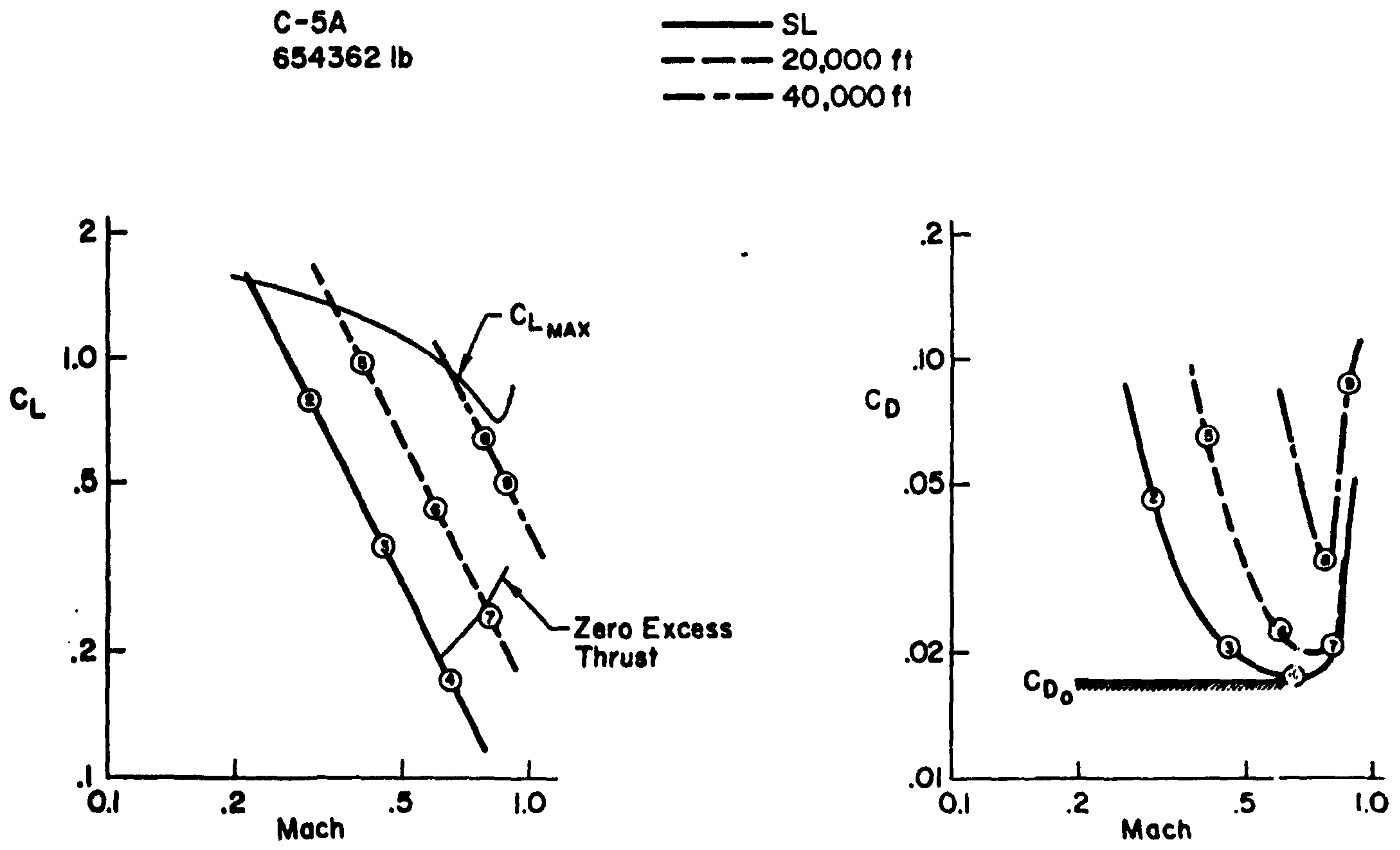
h = sea level

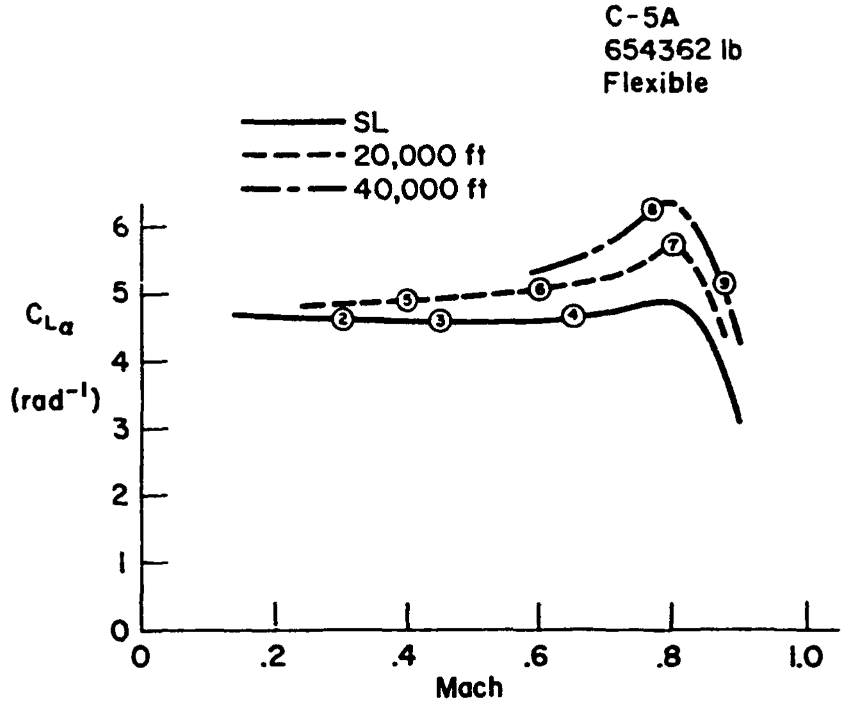
V_{T_o} = 247 ft/sec = 146 kt

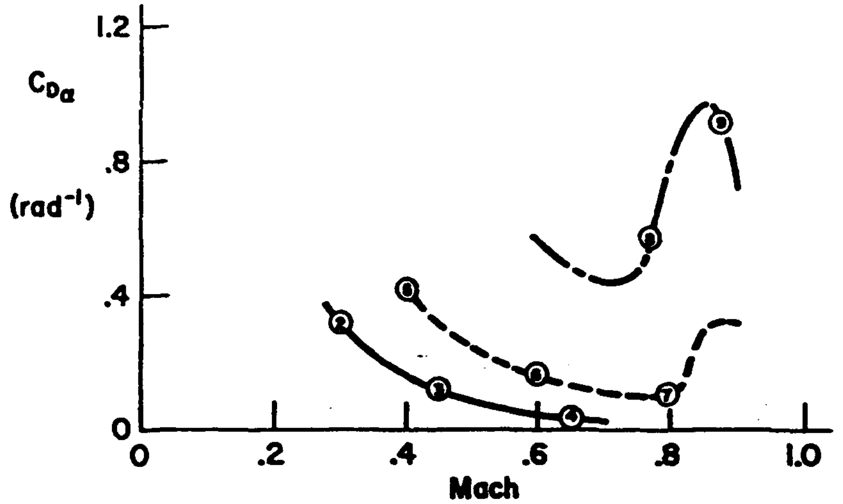
α_o = 2.7°

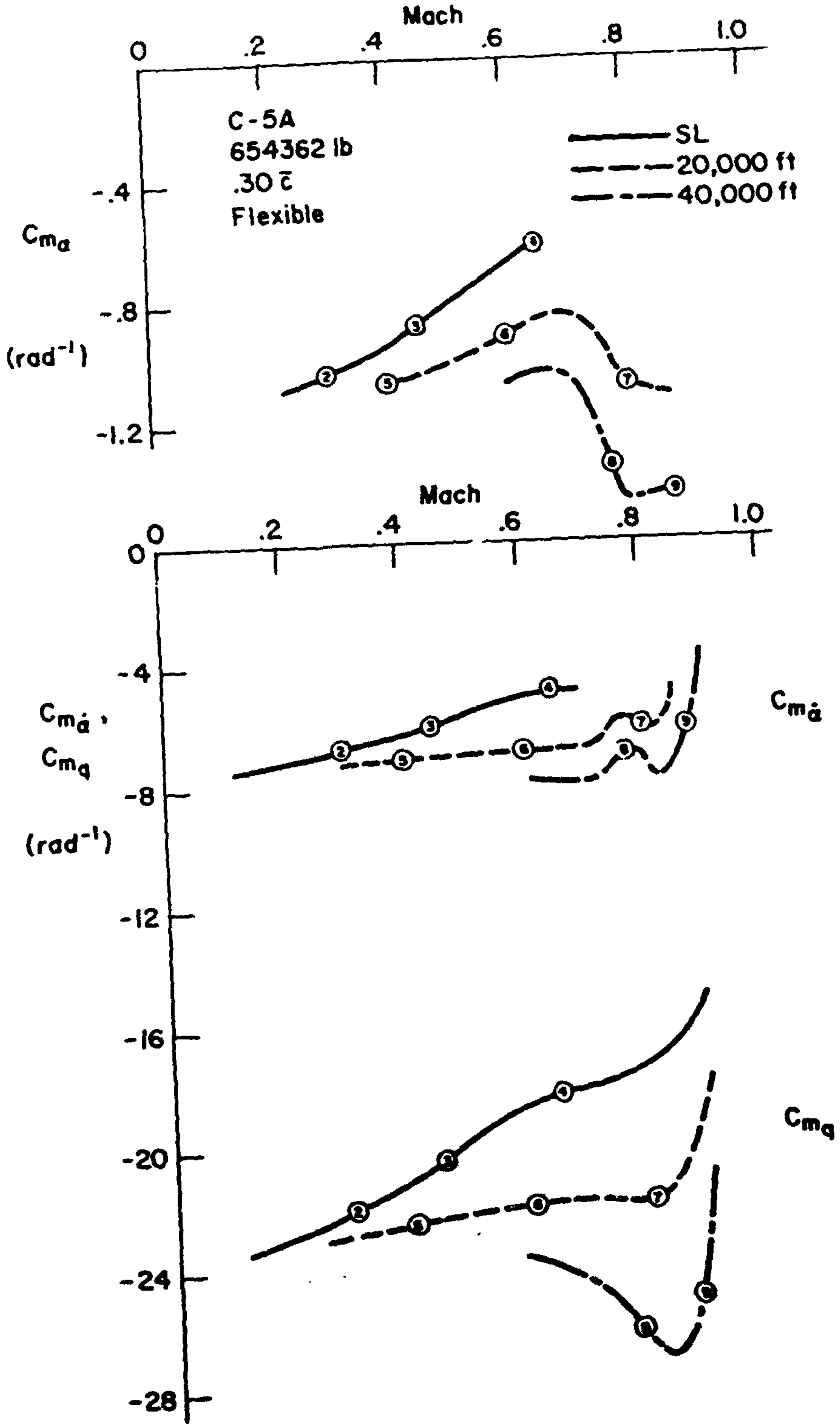
Longitudinal	Lateral-Directional (Stability Axis)	
$C_L = 1.29$	$C_{y_\beta} = -.77$/rad	
$C_D = .145$	$C_{n_\beta} = .075$/rad	
$C_{L_\alpha} = 6.08$/rad	$C_{\ell_\beta} = -.123$/rad	
$C_{D_\alpha} = .622$/rad	$C_{\ell_p} = -.458$/rad	
$C_{m_\alpha} = -.827$/rad	$C_{n_p} = -.098$/rad	
$C_{m_{\dot{\alpha}}} = -8.3$/rad	$C_{\ell_r} = .290$/rad	
$C_{m_q} = -23.2$/rad	$C_{n_r} = -.293$/rad	
$C_{L_{\delta_e}} = .385$/rad	$C_{y_{\delta_a}} = -.0044$/rad	Spoiler
$C_{m_{\delta_e}} = -1.6$/rad	$C_{n_{\delta_a}} = .0091$/rad	Effects
	$C_{\ell_{\delta_a}} = .089$/rad	Included
	$C_{y_{\delta_r}} = .211$/rad	
	$C_{n_{\delta_r}} = -.106$/rad	
	$C_{\ell_{\delta_r}} = .0209$/rad	

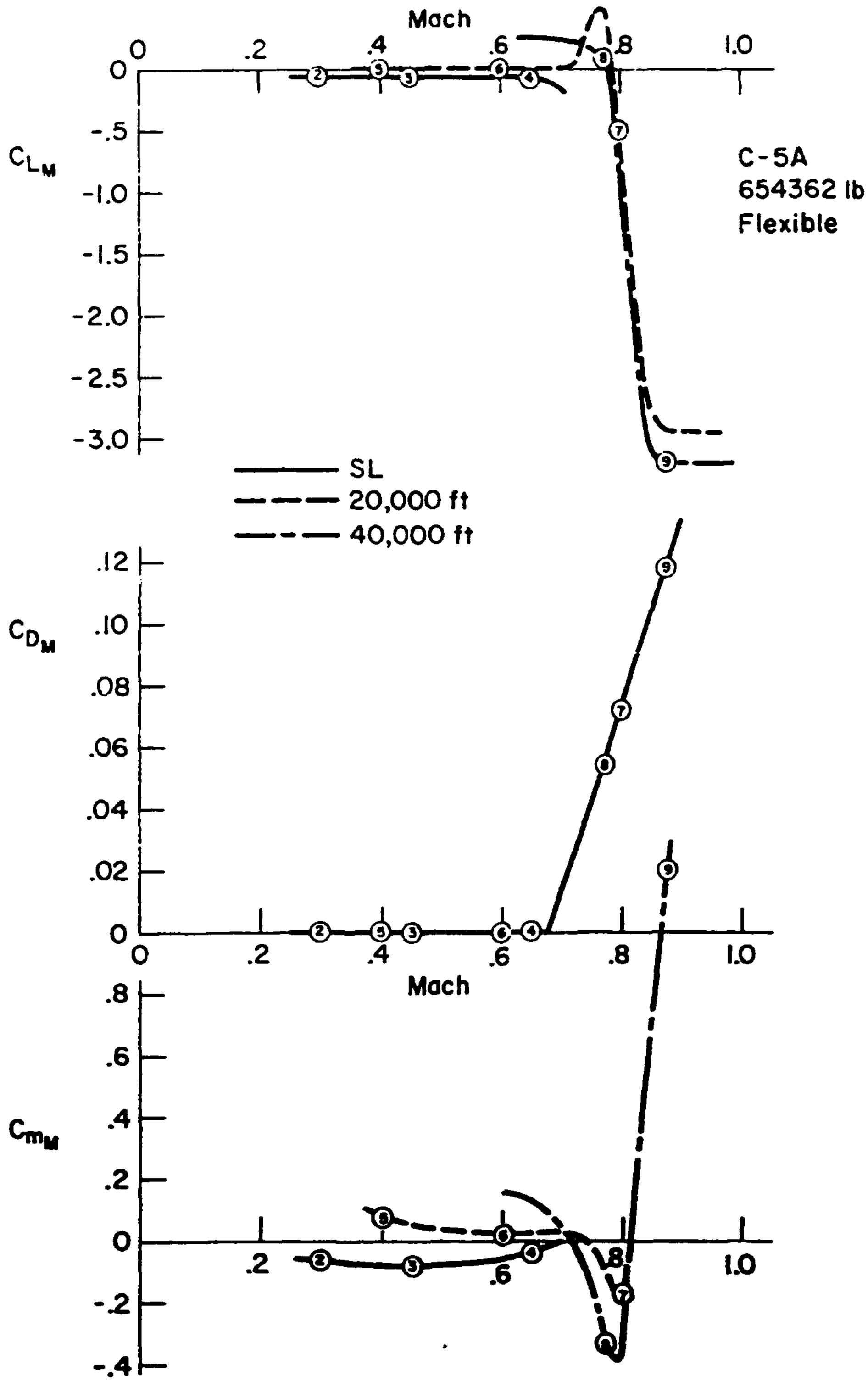

C-5A
654362 lb
Flexible
SL
20,000 ft
40,000 ft
α_0
(deg)
Mach


C-5A
654362 lb
SL
20,000 ft
40,000 ft
C_L
$C_{L_{MAX}}$
Zero Excess Thrust
Mach
C_D
C_{D_0}
Mach

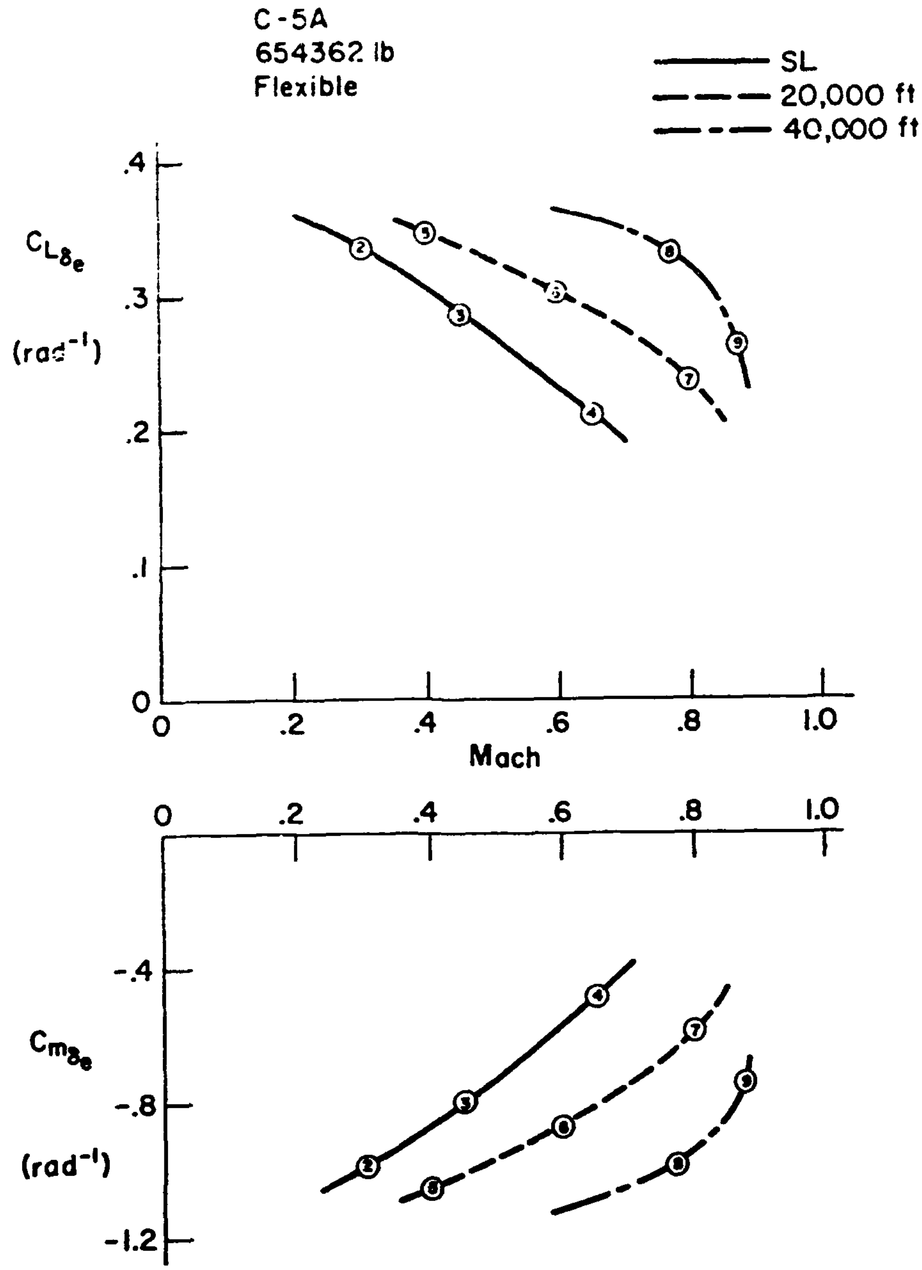

C-5A
654362 lb
Flexible
SL
20,000 ft
40,000 ft
C_{L_α}
(rad⁻¹)
Mach

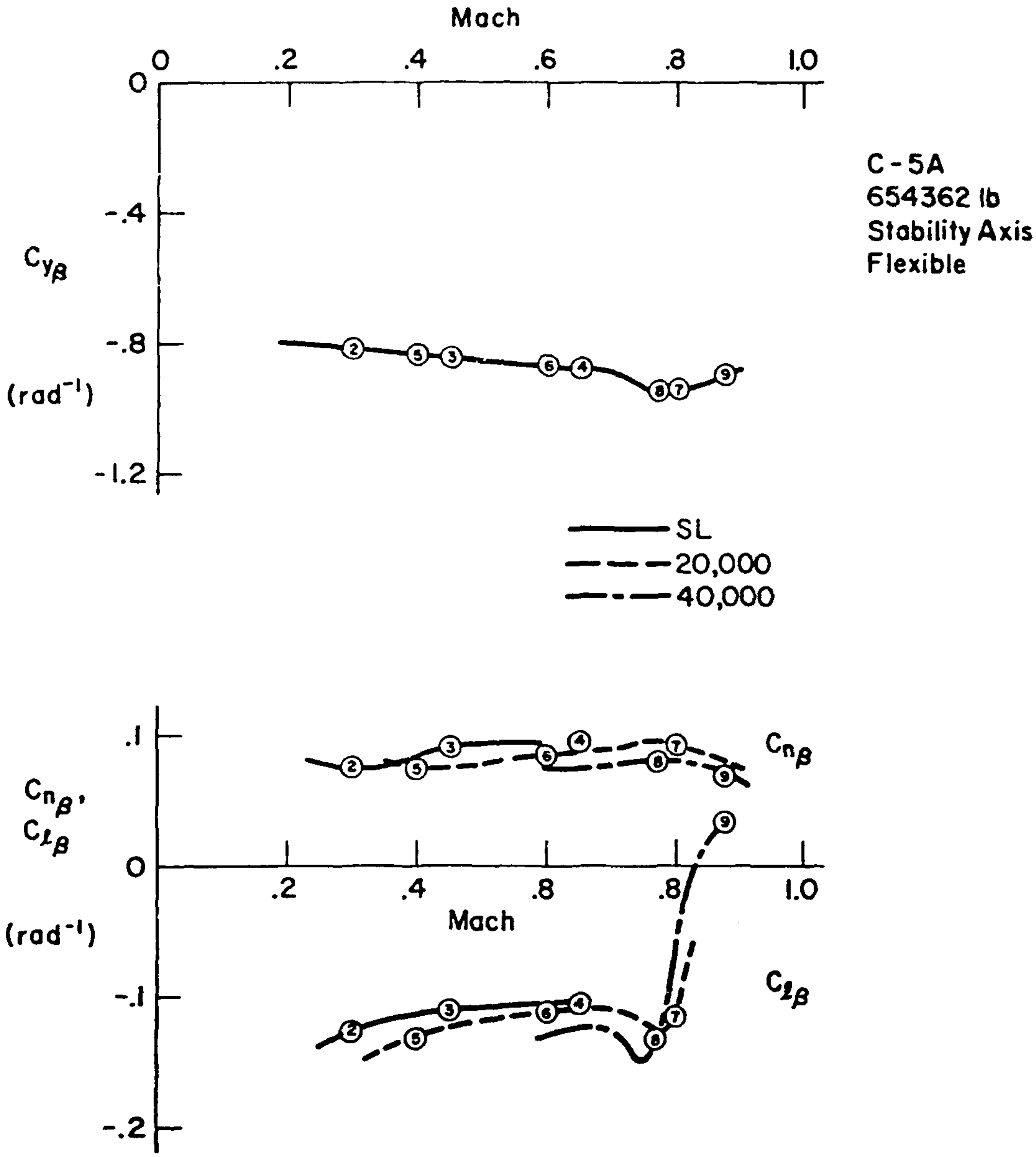

C_{D_α}
(rad⁻¹)
Mach

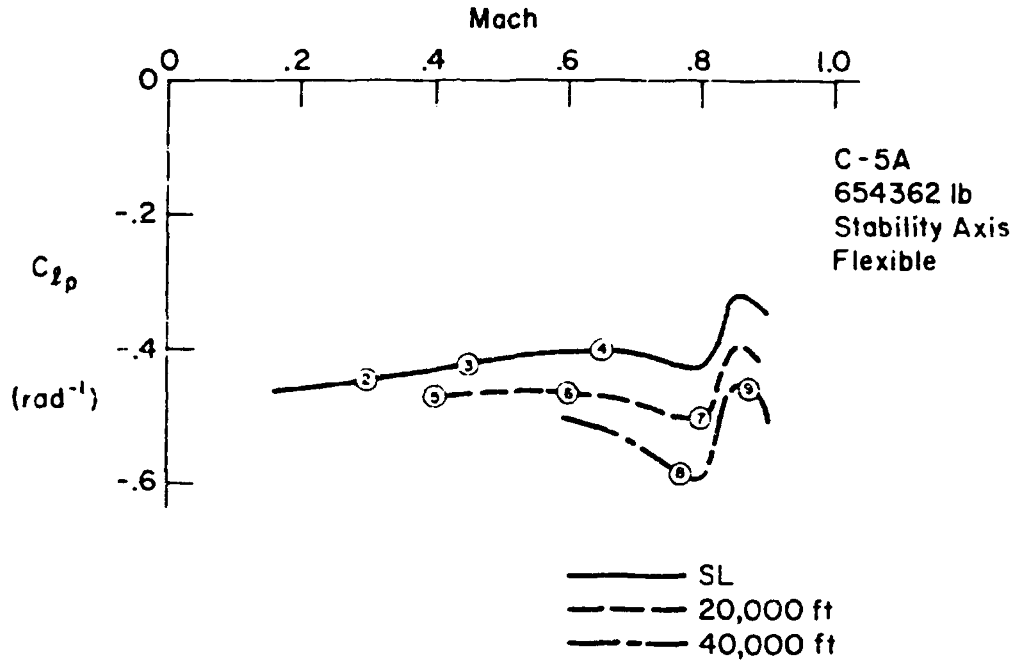

Mach
0
.2
.4
.6
.8
1.0
C-5A
654362 lb
.30 c̄
Flexible
SL
20,000 ft
40,000 ft
-.4
C_{m_α}
-.8
(rad^{-1})
-1.2
Mach
0
.2
.4
.6
.8
1.0
0
-4
$C_{m_{\dot\alpha}}$,
C_{m_q}
-8
(rad^{-1})
-12
-16
-20
-24
-28
$C_{m_{\dot\alpha}}$
C_{m_q}

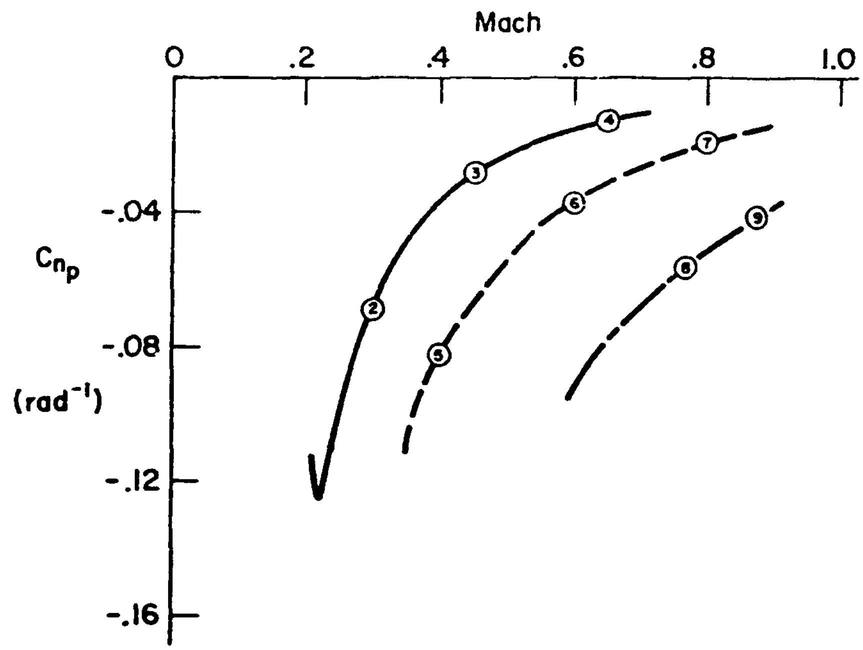


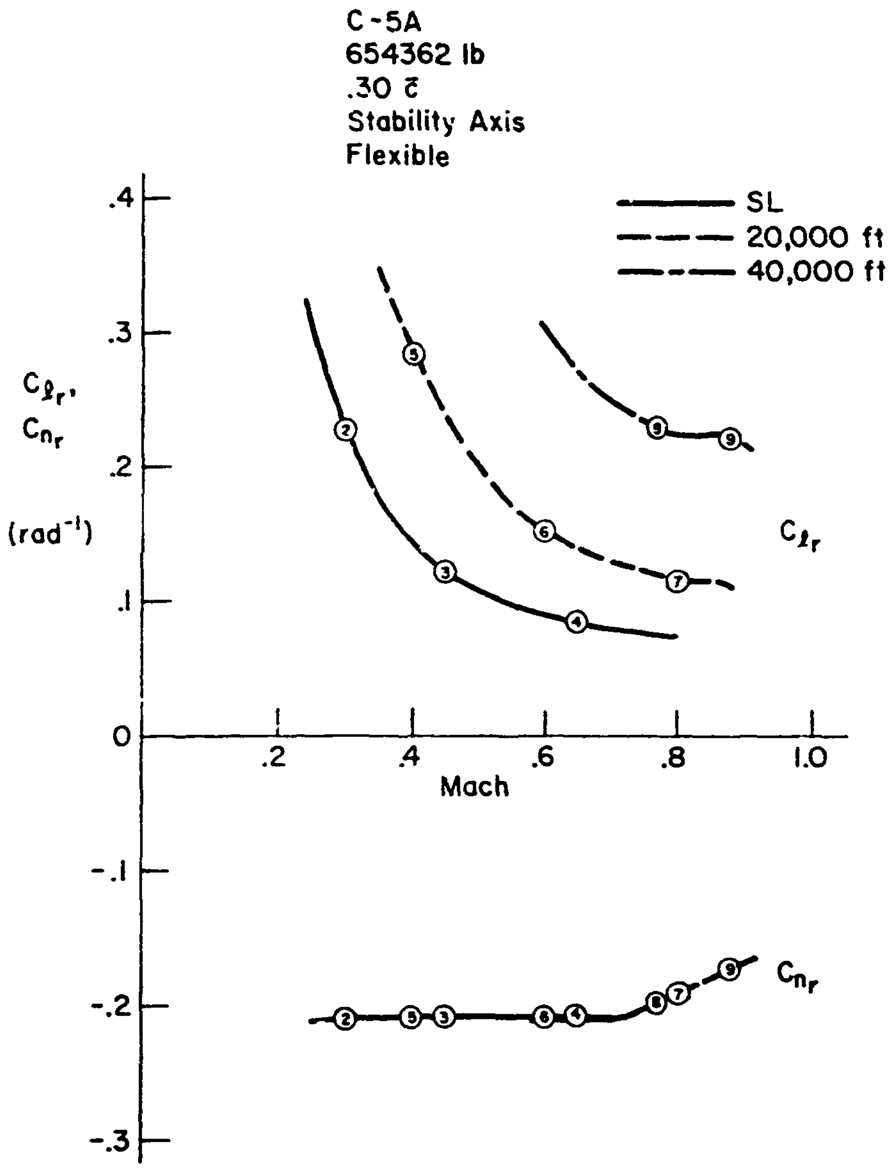
Mach
0
.2
.4
.6
.8
1.0
0
-.5
C_{L_M}
-1.0
-1.5
-2.0
-2.5
-3.0
C-5A
654362 lb
Flexible
SL
20,000 ft
40,000 ft
.12
.10
C_{D_M}
.08
.06
.04
.02
0
Mach
.8
.6
C_{m_M}
.4
.2
-.2
-.4

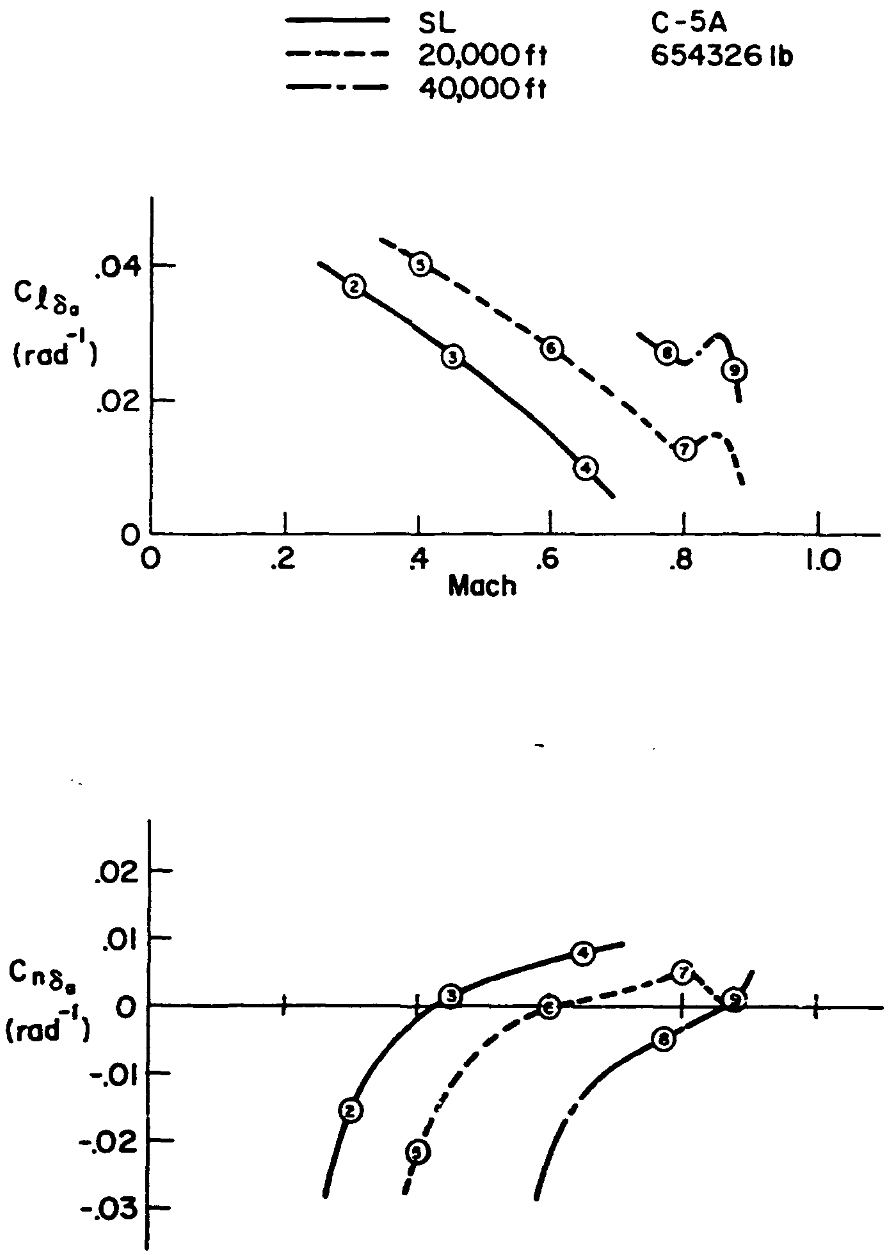

C-5A
654362 lb
Flexible
SL
20,000 ft
40,000 ft
$C_{L_{\delta_e}}$
(rad^{-1})
.4
.3
.2
.1
0
0
.2
.4
.6
.8
1.0
Mach
$C_{m_{\delta_e}}$
(rad^{-1})
-.4
-.8
-1.2

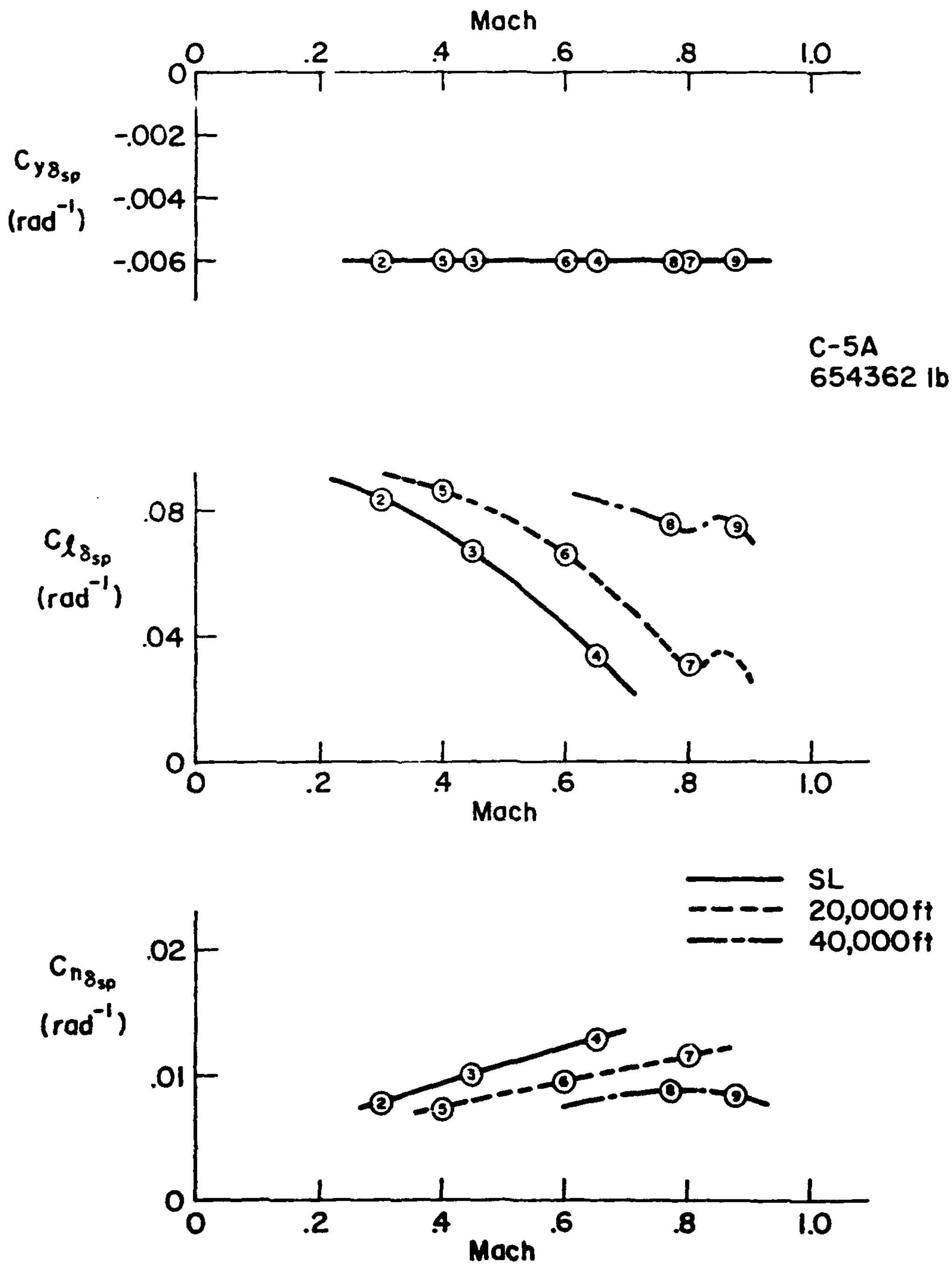

Mach
0
.2
.4
.6
.8
1.0
0
-.4
C_{y_β}
-.8
(rad⁻¹)
-1.2
C-5A
654362 lb
Stability Axis
Flexible
SL
20,000
40,000
.1
C_{n_β},
C_{l_β}
0
(rad⁻¹)
-.1
-.2
.2
.4
.8
.8
1.0
Mach
C_{n_β}
C_{l_β}


Mach
0
.2
.4
.6
.8
1.0
0
-.2
-.4
-.6
C_{ℓ_p}
(rad^{-1})
C-5A
654362 lb
Stability Axis
Flexible
SL
20,000 ft
40,000 ft

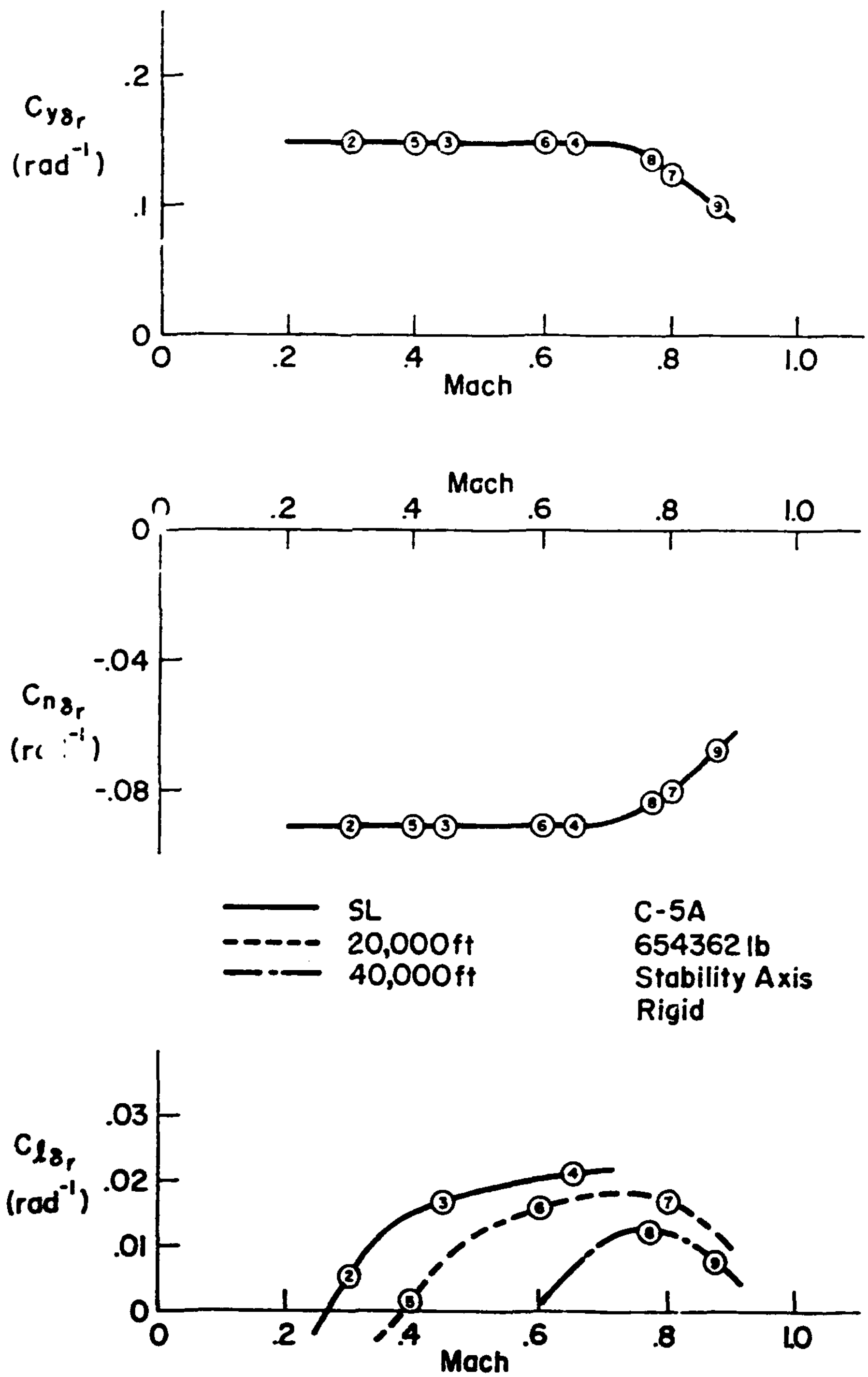

Mach
0
.2
.4
.6
.8
1.0
-.04
-.08
-.12
-.16
C_{n_p}
(rad^{-1})


C-5A
654362 lb
.30 c̄
Stability Axis
Flexible
SL
20,000 ft
40,000 ft
C_{ℓ_r}, C_{n_r}
(rad^{-1})
.4
.3
.2
.1
0
-.1
-.2
-.3
.2
.4
.6
.8
1.0
Mach
C_{ℓ_r}
C_{n_r}


SL
20,000 ft
40,000 ft
C-5A
654326 lb
$C_{\ell\delta_a}$
(rad^{-1})
.04
.02
0
0
.2
.4
.6
.8
1.0
Mach
$C_{n\delta_a}$
(rad^{-1})
.02
.01
0
-.01
-.02
-.03



Mach
0
.2
.4
.6
.8
1.0
-.002
-.004
-.006
$C_{y\delta_{sp}}$ (rad^{-1})
C-5A
654362 lb
$C_{\ell\delta_{sp}}$ (rad^{-1})
.08
.04
SL
20,000 ft
40,000 ft
$C_{n\delta_{sp}}$ (rad^{-1})
.02
.01



Cy δr
(rad⁻¹)
.2
.1
0
0
.2
.4
.6
.8
1.0
Mach
Mach
Cn δr
0
-.04
-.08
SL
20,000 ft
40,000 ft
C-5A
654362 lb
Stability Axis
Rigid
Cl δr
(rad⁻¹)
.03
.02
.01
0
Mach

TABLE X-2

C-5A DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

s = 6200 sq ft, b = 219.20 ft, $\bar{c}$ = 30.10 ft

F/C #	1	2	3	4	5	6	7	8	9
H(FT)	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M(-)	.221	.300	.450	.650	.400	.600	.800	.770	.875
VTO(FPS)	246.	335.	502.	726.	415.	622.	830.	745.	847.
VTO(KTAS)	146.	198.	298.	430.	246.	369.	492.	442.	502.
VTO(KCAS)	146.	198.	298.	430.	181.	275.	373.	233.	269.
W(LBS)	580756.	654399.	654399.	654399.	654399.	654399.	654399.	654399.	654399.
C[illegible]GC)	.300	.300	.300	.300	.300	.300	.300	.300	.300
IX (SLUG-FT SQ)	.191E+8	.278E+8	.278E+8	.278E+8	.278E+8	.278E+8	.278E+8	.278E+8	.278E+8
IY (SLUG-FT SQ)	.313E+8	.318E+8	.318E+8	.318E+8	.318E+8	.318E+8	.318E+8	.318E+8	.318E+8
IZ (SLUG-FT SQ)	.470E+8	.562E+8	.562E+8	.562E+8	.562E+8	.562E+8	.562E+8	.562E+8	.562E+8
IXZ(SLUG-FT SQ)	.250E+7	.246E+7	.246E+7	.246E+7	.246E+7	.246E+7	.246E+7	.246E+7	.246E+7
EPSILON(DEG)	-5.08	-4.91	-4.91	-4.91	-4.91	-4.91	-4.91	-4.91	-4.91
Q(PSF)	72.2	133.	300.	626.	109.	245.	436.	164.	211.
QC(PSF)	73.0	136.	315.	695.	113.	268.	510.	189.	255.
ALPHA(DEG)	2.70	7.30	1.60	-.500	5.00	2.20	.100	3.50	4.90
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7
LZP(FT)	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10
ITH(DEG)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
XI(DEG)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.[illegible]
LTH(FT)	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50

TABLE X-3

C-5A LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
XU *	-.0214	-.00343	-.00583	-.00970	-.00297	-.00313	-.0150	-.00379	-.0330
ZU *	-.231	-.121	-.104	-.0915	-.0913	-.0798	-.0112	-.0605	.168
MU *	-.778E-5	.000232	-.612E-4	-.000185	.000277	.930E-4	-.000433	-.000233	.00167
XW	.0957	.130	.0686	.0236	.106	.0440	.0224	.0304	.000142
ZW	-.634	-.572	-.834	-1.23	-.405	-.618	-.925	-.427	-.387
MW	-.00145	-.00240	-.00309	-.00309	-.00163	-.00210	-.00333	-.00176	-.00196
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-.000884	-.000698	-.000630	-.000514	-.000392	-.000386	-.000347	-.000182	-.000158
MQ	-.610	-.773	-1.08	-1.39	-.525	-.766	-1.02	-.506	-.551
XDE	.450	1.73	.728	-.350	1.79	.861	.0545	1.00	1.46
ZDE	-9.53	-13.5	-26.1	-40.1	-11.3	-22.4	-31.2	-16.4	-17.0
MDE	-.688	-.775	-1.41	-1.76	-.672	-1.25	-1.51	-.941	-.918
XDTH	.554E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4
ZDTH	-.193E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5
MDTH	.144E-6	.142E-6	.142E-6	.142E-6	.142E-6	.142E-6	.142E-6	.142E-6	.142E-6

TABLE X-4

C-5A ELEVATOR TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
Z(DET)1	.100	.0351	.0612	.232	.0283	.0271	(-.0487)	.0506	.453
W(DET)1	.119	.104	.0594	.0213	.0969	.0638	(.0648)	.0110	.0716
Z(DET)2	.843	.706	.712	.752	.577	.608	.579	.435	.373
W(DET)2	.865	1.12	1.57	1.99	.947	1.34	1.93	1.23	1.40
NUMERATORS									
N(U /DE)									
A(U)	.450	1.73	.728	-.350	1.79	.861	.0545	1.00	1.46
1/T(U)1	15.6	19.1	26.1	1.92	24.4	34.2	2.29	42.4	.287
1/T(U)2	(.482)	(.202)	(.196)	-2.58	(.239)	(.442)	(.736)	(.593)	.539
1/T(U)3	(1.40)	(.639)	(1.36)	37.9	(.439)	(.892)	(18.3)	(.532)	45.6
N(W /DE)									
A(W)	-9.53	-13.5	-26.1	-40.1	-11.3	-22.4	-31.2	-16.4	-17.0
1/T(W)1	18.4	19.8	28.2	33.3	24.8	35.5	41.1	43.1	-.0651
1/T(W)2	(.0730)	(.0308)	(.0428)	(.0751)	(.0304)	(.0323)	(.864)	(.0493)	.0806
1/T(W)3	(.170)	(.107)	(.0795)	(.0609)	(.0852)	(.0642)	(.00922)	(.0490)	46.1
N(THE/DE)									
A(THE)	-.680	-.765	-1.39	-1.74	-.667	-1.24	-1.50	-.938	-.915
1/T(THE)1	.0610	.0342	.0149	.0115	.0302	.00913	.0161	.00817	.0316
1/T(THE)2	.582	.505	.777	1.17	.353	.578	.862	.394	.350
N(HD /DE)									
A(HD)	9.54	13.6	26.1	40.1	11.5	22.4	31.2	16.5	17.1
1/T(HD)1	.00211	-.00248	.00448	.00852	-.00376	-.000206	.0159	-.000658	.0422
1/T(HD)2	-2.88	-2.68	-3.94	-5.26	-2.66	-4.00	-5.24	-3.78	-3.73
1/T(HD)3	3.73	3.70	5.34	7.02	3.37	5.01	6.55	4.43	4.39
N(AZP/DE)									
A(AZP)	46.0	49.0	87.7	102.	43.2	79.2	91.2	60.2	57.7
1/T(AZP)1	-.0179	.0189	-.00337	.000558	.0169	.00414	-.682E-4	.00430	-.00226
1/T(AZP)2	.0197	-.0215	.00784	.00795	-.0211	-.00436	.0157	-.00501	.0440
Z(AZP)1	.198	.124	.121	.124	.0990	.0980	.104	.0783	.0556
W(AZP)1	1.50	1.65	2.50	3.81	1.52	2.38	3.43	2.14	2.20

TABLE X-5

C-5A THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
Z(DET)1	.100	.0351	.0612	.232	.0283	.0271	(-.0487)	.0506	.453
W(DET)1	.119	.104	.0594	.0213	.0969	.0638	(.0648)	.0110	.0716
Z(DET)2	.843	.706	.712	.752	.577	.608	.579	.435	.373
W(DET)2	.865	1.12	1.57	1.99	.947	1.34	1.93	1.23	1.40
NUMERATORS									
N(U /DTH)									
A(U)	.884E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4
1/T(U)1	-.0712	-.0525	-.0336	-.0290	-.0552	-.0351	-.0241	-.0308	-.0252
Z(U)1	.836	.666	.703	.758	.508	.596	.583	.399	.339
W(U)1	.896	1.13	1.58	2.00	.939	1.33	1.93	1.21	1.31
N(W /DTH)									
A(W)	-.193E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5	-.172E-5
1/T(W)1	-11.0	-24.0	-37.5	-55.6	-31.4	-48.5	-.00482	-59.3	-.0142
1/T(W)2	(-.726)	(-.0564)	(-.589)	(-.934)	(.414)	(.0188)	-.138	(-.967)	.602
1/T(W)3	(.223)	(.108)	(.0862)	(.0667)	(.0776)	(.0651)	-66.9	(.0552)	-74.7
N(THE/DTH)									
A(THE)	.148E-6	.147E-6	.143E-6	.142E-6	.145E-6	.143E-6	.142E-6	.142E-6	.142E-6
1/T(THE)1	(.930)	(.817)	.143	.0281	(.847)	.157	-.116	.0164	.141
1/T(THE)2	(.398)	(.397)	.728	1.19	(.314)	.529	.945	.358	.868
N(HD /DTH)									
A(HD)	.454E-5	.795E-5	.309E-5	.129E-5	.938E-5	.360E-5	.180E-5	.471E-5	.591E-5
1/T(HD)1	.137	.172	.0967	.0221	.159	.104	-.114	.00332	.286
Z(HD)1	.715	.451	.345	.235	.355	.276	.112	.229	-.117
W(HD)1	2.71	2.24	4.82	10.3	1.87	4.19	7.98	3.37	3.05
N(AZP/DTH)									
A(AZP)	-.140E-4	-.13[illegible]E-4	-.134E-4	-.133E-4	-.136E-4	-.134E-4	-.133E-4	-.131E-4	-.134E-4
1/T(AZP)1	-.00740	-.0130	-.00191	.000443	-.0131	-.00209	-.674E-4	-.00405	-.00308
1/T(AZP)2	.147	.217	.103	.0220	.206	.117	-.114	.00820	.333
Z(AZP)1	.501	.310	.269	.250	.245	.214	.179	.166	.00630
W(AZP)1	1.53	1.56	2.26	3.21	1.41	2.12	2.93	1.91	1.87

TABLE X-6

C-5A STICK FORCE TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
Z(DET)1	.110	.0376	.0646	.247	.0304	.0285	(-.0454)	.0462	.459
W(DET)1	.110	.101	.0566	.0197	.0928	.0603	(.0613)	.0104	.0693
Z(DET)2	.783	.682	.677	.693	.553	.575	.543	.415	.361
W(DET)2	.936	1.16	1.65	2.17	.991	1.42	2.06	1.30	1.45
NUMERATORS									
N(U /FST)									
A(U)	-.00201	-.00430	-.00132	.000637	-.00542	-.00196	-.989E-4	-.00211	-.00263
1/T(U)1	15.6	19.1	26.1	1.92	24.4	34.2	2.79	42.4	.787
1/T(U)2	(.482)	(.202)	(.196)	-2.58	(.239)	(.442)	(.736)	(.593)	.539
1/T(U)3	(1.40)	(.639)	(1.36)	37.9	(.439)	(.892)	(18.2)	(.532)	45.6
N(W /FST)									
A(W)	.0427	.0335	.0472	.0730	.0342	.0405	.0567	.0345	.0307
1/T(W)1	18.4	19.8	28.2	33.3	24.8	35.5	41.1	43.1	-.0651
1/T(W)2	(.0730)	(.0308)	(.0428)	(.0751)	(.0304)	(.0323)	(.864)	(.0493)	.0806
1/T(W)3	(.170)	(.107)	(.0795)	(.0609)	(.0852)	(.0642)	(.00922)	(.0490)	46.1
N(THE/FST)									
A(THE)	.00305	.00190	.00252	.00317	.00202	.00225	.00272	.00197	.00165
1/T(THE)1	.0610	.0342	.0149	.0115	.0302	.00913	.0161	.00817	.0316
1/T(THE)2	.42	.505	.777	1.17	.353	.578	.862	.394	.350
N(HD /FST)									
A(HD)	-.0428	-.0338	-.0472	-.0730	-.0347	-.0405	-.0567	-.0345	-.0308
1/T(HD)1	.00211	-.00248	.00448	.00852	-.00376	-.000206	.0159	-.000655	.0422
1/T(HD)2	-2.88	-2.68	-3.94	-5.26	-2.65	-4.00	-5.24	-3.78	-3.73
1/T(HD)3	3.73	3.70	5.34	7.02	3.37	5.01	6.55	4.43	4.39
N(AZP/FST)									
A(AZP)	-.206	-.122	-.159	-.186	-.131	-.143	-.166	-.126	-.134
1/T(AZP)1	-.0179	.0189	-.00337	.000558	.0169	.00414	-.682E-4	.00430	-.00226
1/T(AZP)2	.0197	-.0215	.00784	.00756	-.0211	-.00436	.0159	-.00501	.0460
Z(AZP)1	.198	.124	.121	.124	.0990	.0980	.104	.0783	.0556
W(AZP)1	1.50	1.65	2.50	3.01	1.92	2.38	3.43	2.14	2.20

TABLE X-7

C-5A THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1		3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
Z(DET)1	.110	.0376	.0646	.247	.0304	.0285	(-.0454)	.0462	.459
W(DET)1	.110	.101	.0566	.0197	.0928	.0603	(.0613)	.0104	.0693
Z(DET)2	.783	.682	.677	.693	.553	.575	.543	.415	.361
W(DET)2	.936	1.16	1.65	2.17	.991	1.42	2.06	1.30	1.45
NUMERATORS									
N(U /DTH)									
A(U)	.554E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4	.491E-4
1/T(U)1	-.0636	-.0501	-.0307	-.0248	-.0518	-.0317	-.0213	-.0282	-.0238
Z(U)1	.781	.644	.669	.699	.486	.563	.547	.380	.327
W(U)1	.959	1.17	1.67	2.18	.983	1.41	2.06	1.28	1.35
N(W /DTH)									
A(W)	-.195E-5	-.173E-5	-.174E-5	-.175E-5	-.173E-5	-.173E-5	-.174E-5	-.173E-5	-.173E-5
1/T(W)1	-.211	-23.6	-36.7	-.0391	-30.9	-47.6	-.00478	-98.3	-.0138
1/T(W)2	-.292	(-.168)	(-.744)	-.117	(.292)	(-.115)	-.142	(-.944)	.628
1/T(W)3	-10.5	(.111)	(.0875)	-53.5	(.0798)	(.0659)	-65.4	(.0559)	-73.9
N(THE/DTH)									
A(THE)	.146E-6	.146E-6	.142E-6	.141E-6	.144E-6	.142E-6	.141E-6	.142E-6	.142E-6
1/T(THE)1	(.853)	(.867)	.149	.0288	(.826)	.163	-.117	.0168	.137
1/T(THE)2	(.402)	(.400)	.717	1.20	(.316)	.519	.964	.353	.906
N(HD /DTH)									
A(HD)	.456E-5	.796E-5	.311E-5	.132E-5	.540E-5	.362E-5	.183E-5	.473E-5	.592E-5
1/T(HD)1	.135	.169	.0962	.0228	.155	.109	-.113	.00322	.284
Z(HD)1	.713	.449	.345	.235	.353	.275	.112	.228	-.116
W(HD)1	2.73	2.26	4.84	10.2	1.90	4.21	7.98	3.39	3.07
N(AZP/DTH)									
A(AZP)	-.139E-4	-.137E-4	-.134E-4	-.132E-4	-.135E-4	-.133E-4	-.133E-4	-.133E-4	-.133E-4
1/T(AZP)1	-.00740	-.0130	-.00191	.000443	-.0131	-.00209	-.674E-4	-.00405	-.00308
1/T(AZP)2	.146	.216	.103	.0220	.206	.117	-.114	.00828	.334
Z(AZP)1	.486	.307	.267	.249	.242	.212	.1[illegible]	.163	.0118
W(AZP)1	1.54	1.57	2.28	3.25	1.42	2.14	2.9[illegible]	1.93	1.88

TABLE X-8

C-5A LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS OFF

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
STICK FIXED									
D(G)/D(U) (DEG/KT)	-.00658	.00729	-.0135	-.0256	.0112	.000581	-.0478	.00193	-.127
NZA (G/RAD)	4.54	5.26	11.6	25.0	4.71	11.0	21.5	9.05	9.07
DE/G (DEG/G)	13.2	16.7	8.23	4.91	15.6	7.27	6.38	10.1	12.7
CAP (RAD/SEC/SEC/G)	.156	.224	.200	.149	.182	.158	.167	.166	.203
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	--	(14.2)	--	--
1/C(1/10)	4.28	2.72	2.77	3.11	1.93	2.09	1.94	1.32	1.10
STICK FREE									
FST/KT (LB/KT)	-.292	-.687	-.232	-.0258	-.561	-.292	.265	-.0122	-.915
FST/G (LB/G)	60.2	127.	88.7	55.2	59.1	79.3	70.5	93.2	132.

TABLE X-9

C-5A LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
YV	-.0775	-.0995	-.153	-.231	-.0673	-.106	-.151	-.0636	-.0684
YB	-19.1	-33.3	-76.8	-168.	-27.9	-65.8	-125.	-47.4	-58.0
LB'	-.635	-.863	-1.60	-3.07	-.747	-1.33	-2.38	-1.08	.333
NB'	.110	.150	.560	1.32	.106	.432	.885	.237	.386
LP'	-1.09	-.997	-1.36	-1.85	-.707	-.988	-1.42	-.706	-.632
NP'	-.156	-.150	-.113	-.107	-.120	-.0921	-.0906	-.0776	-.0716
LR'	.613	.399	.344	.360	.324	.282	.303	.233	.256
NR'	-.231	-.187	-.310	-.455	-.113	-.203	-.251	-.0991	-.0930
Y*DA	-.000443	-.947E-4	-.000142	-.000205	-.625E-4	-.937E-4	-.000125	-.522E-4	-.593E-4
L'DA	.461	.321	.516	.446	.284	.434	.370	.298	.357
N'DA	.0522	-.0126	.0500	.165	-.0212	.0343	.0850	.00618	.0414
Y*DR	.0212	.0181	.0271	.0352	.0119	.0179	.0200	.00910	.00760
L'DR	.105	.0852	.229	.500	.0625	.187	.292	.112	.107
N'DR	-.213	-.282	-.639	-1.34	-.231	-.522	-.830	-.324	-.338

TABLE X-10

C-5A AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
1/T(DET)1	.0283	.0162	.0161	.0139	.00800	.0103	.00788	.00520	-.0264
1/T(DET)2	1.13	1.04	1.44	1.96	.766	1.07	1.51	.793	.582
Z(DET)1	.226	.184	.209	.227	.103	.138	.144	.0564	.197
W(DET)1	.530	.608	.875	1.25	.549	.771	1.03	.618	.605
NUMERATORS									
N(B /DA)									
A(B)	-.000443	-.947E-4	-.000142	-.000205	-.625E-4	-.937E-4	-.000125	-.522E-4	-.593E-4
1/T(B)1	.203	.0473	.292	-.0455	.0184	.145	-.0595	.0389	.0932
1/T(B)2	-2.75	1.78	-1.09	1.48	1.11	-1.95	.917	2.72	-1.64
1/T(B)3	72.7	-564.	253.	844.	-1046.	191.	676.	-232.	183.
N(P /DA)									
A(P)	.461	.321	.516	.446	.284	.434	.370	.298	.357
1/T(P)1	-.00541	-.0105	-.00167	.000367	-.0106	-.00190	-.655E-4	-.00257	-.00318
Z(P)1	.422	.382	.284	.256	.349	.222	.194	.165	.163
W(P)1	.456	.368	.877	1.62	.238	.749	1.22	.515	.596
N(R /DA)									
A(R)	.0522	-.0126	.0500	.165	-.0212	.0343	.0850	.00618	.0414
1/T(R)1	.505	-.224	.796	1.72	-.133	.574	1.20	.327	.333
Z(R)1	-.560	(.258)	-.295	.0953	(.164)	-.413	-.0352	(-.612)	-.215
W(R)1	.645	(4.88)	.771	.410	(2.31)	.782	.448	(-2.69)	.584
N(PHI/DA)									
A(PHI)	.464	.320	.518	.444	.281	.435	.370	.298	.360
Z(PHI)1	.415	.340	.284	.254	.276	.221	.194	.159	.160
W(PHI)1	.452	.364	.875	1.62	.235	.748	1.22	.515	.595
N(AYP/DA)									
A(AYP)	7.89	1.54	8.20	17.3	.542	6.26	9.84	2.88	6.22
1/T(AYP)1	.273	.0515	-.334	-.0418	.0191	.178	-.0507	.0453	.110
1/T(AYP)2	-.451	-3.35	.339	1.31	-7.49	-.396	.774	-.882	-.289
Z(AYP)1	.184	.284	.209	.114	.353	.208	.0941	.305	.720
W(AYP)1	.595	.753	.971	1.45	.693	.866	1.22	.728	.698

TABLE X-11

C-5A RUDDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
1/T(DET)1	.0283	.0162	.0161	.0139	.00800	.0103	.00780	.00420	-.0264
1/T(DET)2	1.13	1.04	1.44	1.96	.766	1.07	1.51	.793	.562
Z(DET)1	.226	.184	.209	.227	.103	.138	.144	.0564	.197
W(DET)1	.530	.608	.875	1.25	.549	.771	1.03	.618	.605
NUMERATORS									
N(B /DR)									
A(B)	.0212	.0181	.0271	.0392	.0119	.0179	.0200	.00910	.00765
1/T(B)1	-.0559	-.0424	-.0120	-.00394	-.0423	-.0123	-.00571	-.0140	-.0162
1/T(B)2	1.25	1.03	1.42	1.93	.718	1.03	1.47	.733	.644
1/T(B)3	10.4	16.3	24.1	34.6	20.1	29.7	41.7	36.4	45.6
N(P /DR)									
A(P)	.105	.0852	.229	.500	.0625	.187	.292	.112	.107
1/T(P)1	-.00568	-.0117	-.00173	.000377	-.0119	-.00194	-.665E-4	-.00260	-.00235
Z(P)1	(.719)	(1.19)	(1.70)	(2.42)	(1.17)	(1.55)	(2.15)	(1.44)	-.262
W(P)1	(-1.78)	(-2.39)	(-2.38)	(-2.94)	(-2.32)	(-2.16)	(-2.78)	(-2.03)	1.18
N(R /DR)									
A(R)	-.213	-.282	-.639	-1.34	-.231	-.522	-.830	-.324	-.338
1/T(R)1	1.20	1.02	1.43	1.95	.694	1.04	1.49	.733	-.141
1/T(R)2	(.0541)	(.201)	(.211)	(.293)	(.190)	(.151)	(.192)	(.117)	.181
1/T(R)3	(.251)	(.276)	(.251)	(.243)	(.282)	(.242)	(.232)	(.242)	.676
N(PHI/DR)									
A(PHI)	.0949	.0490	.212	.511	.0259	.167	.290	.0424	.0783
Z(PHI)1	(.704)	(1.21)	(1.70)	(2.42)	(1.29)	(1.58)	(2.16)	(1.49)	-.404
W(PHI)1	(-2.01)	(-4.16)	(-2.57)	(-2.88)	(-5.22)	(-2.39)	(-2.79)	(-2.39)	[illegible]
N(AYP/DR)									
A(AYP)	-11.2	-16.3	-36.7	-77.2	-13.4	-30.0	-48.9	-18.9	-20.3
1/T(AYP)1	-.0688	-.0481	-.0180	-.00808	-.0442	-.0163	-.00822	-.0162	-.0156
1/T(AYP)2	1.32	.599	1.39	1.89	.645	.981	1.42	.663	.721
Z(AYP)1	.0988	.170	.0992	.0316	.180	.0991	.0887	.111	.0362
W(AYP)1	.577	.770	1.09	1.56	.745	1.04	1.38	.924	.871

TABLE X-12

C-5A LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DR PERIOD (SEC)	12.2	10.5	7.35	5.16	11.5	8.23	6.16	10.2	10.6
1/C(1/2)	2.11	1.69	1.94	2.12	.939	1.26	1.31	.512	1.82
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--	26.3
P(1)	.387	.226	.371	.431	.242	.398	.386	.310	--
P(2)	.161	-.000993	.308	.326	-.117	.324	.291	.163	--
P(3)	.215	.132	.316	.355	.180	.359	.339	.310	--
P(2)/P(1)	.416	-.00440	.828	.755	-.484	.813	.753	.527	--
P(OSC)/P(AV)	.413	1.01	.0939	.140	3.50	.0778	.110	.310	--
W(PHI)/W(D)	.854	.999	1.00	1.30	.428	.971	1.18	.834	.983
DEL-B-MAX	.522	.395	.0537	.119	.530	.0811	.0794	.186	.104
PHI TC BETA, PHASE	-288.	60.8	-307.	46.7	56.6	-309.	50.1	-308.	183.
PHI TO BETA	1.10	1.34	1.25	1.24	1.63	1.47	1.42	1.92	.882
PHI TO VE	.255	.230	.142	.0977	.309	.186	.135	.296	.120

C-5A DATA SOURCES

C-5 Flight Control Report (Aerospace Vehicle) Stability and Control, Lockheed-Georgia Rept. No. LG1US42-1-1, 8 Feb. 1966

SECTION XI

XB-70A

XB-70A BACKGROUND

The XB-70A was originally designed as a weapons systems with long range supersonic cruise capabilities. The two aircraft built became research aircraft to explore SST-related problems.

The two XB-70A's were identical except that the first airplane (XB-70A-1) had zero geometric dihedral while the second had 5 deg geometric dihedral. The first airplane is considered here.

Pitch control employs interconnected elevon and canard surfaces except in takeoff and landing where the canard is locked and a fixed canard flap is used. Roll control is obtained through differential action of the elevons. Yaw control is provided by rotation of the vertical stabilizers about a 45 deg hinge line.

The airplane is equipped with stability augmentation in all axes.

Data shown here is a composite of many sources. The object was to use flight test data where possible.

XB-70A

Nominal Configuration

Tips Folded According to Flight Condition

50% Internal Fuel

W = 384524 lb

c.g. at 0.218 $\bar{c}$, W.L. −7.2

$$\left.\begin{array}{l} I_x = 1.8 \times 10^6 \text{ slug-ft}^2 \\ I_y = 19.9 \times 10^6 \text{ slug-ft}^2 \\ I_z = 22.1 \times 10^6 \text{ slug-ft}^2 \\ I_{xz} = -0.88 \times 10^6 \text{ slug-ft}^2 \end{array}\right\} \text{Body Axis}$$

Power Approach Configuration

Tips Extended

19% Internal Fuel

Canard Flaps Down

Gear Down

W = 300000 lb

c.g. at 0.235 $\bar{c}$

$$\left.\begin{array}{l} I_x = 1.45 \times 10^6 \text{ slug-ft}^2 \\ I_y = 16 \times 10^6 \text{ slug-ft}^2 \\ I_z = 17.2 \times 10^6 \text{ slug-ft}^2 \\ I_{xz} = -0.6 \times 10^6 \text{ slug-ft}^2 \end{array}\right\} \text{Body Axis}$$

Flight Envelope

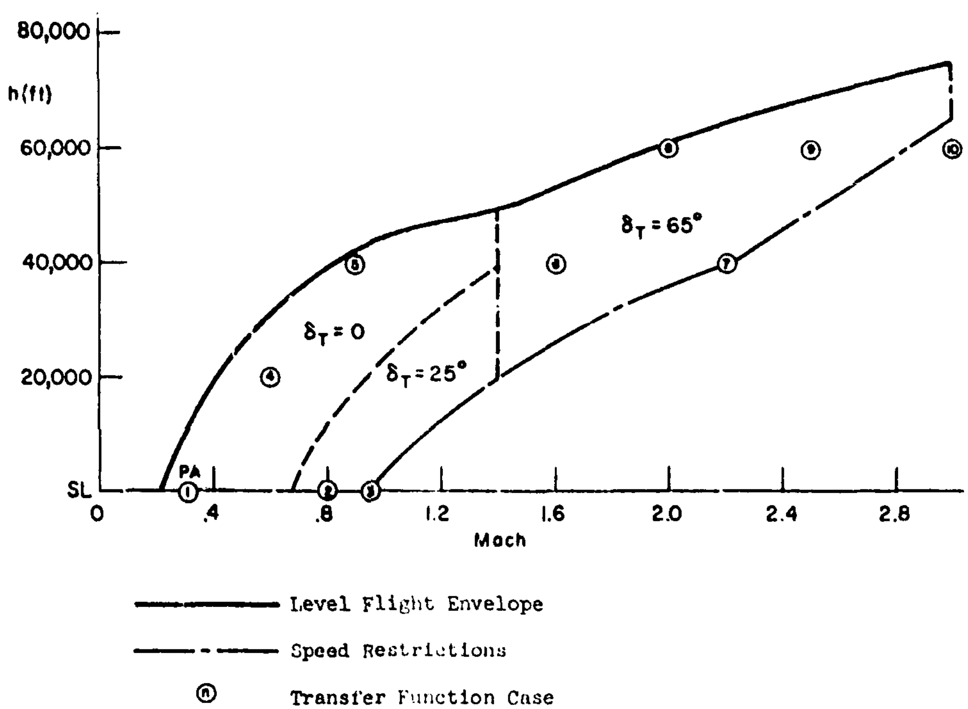


Figure XI-1. XB-70A Flight Conditions

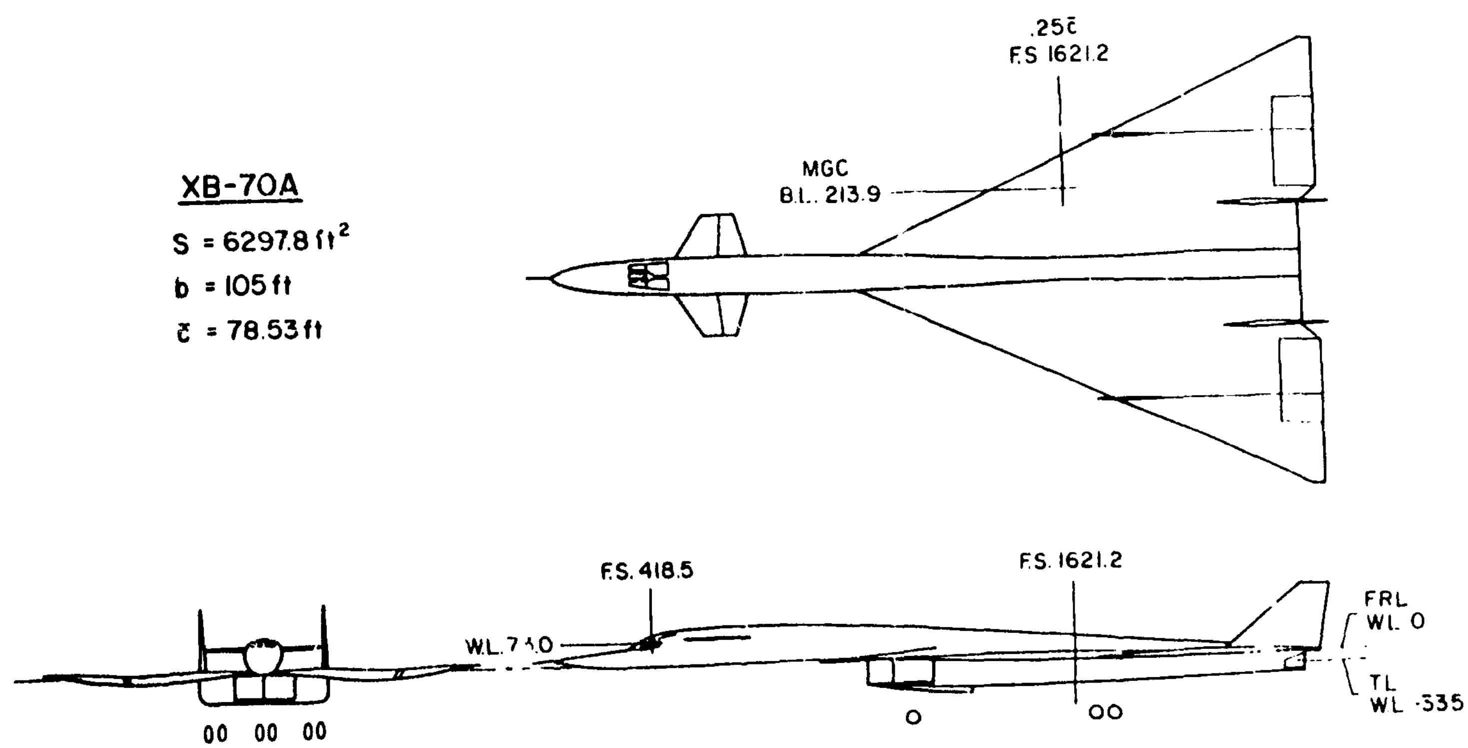
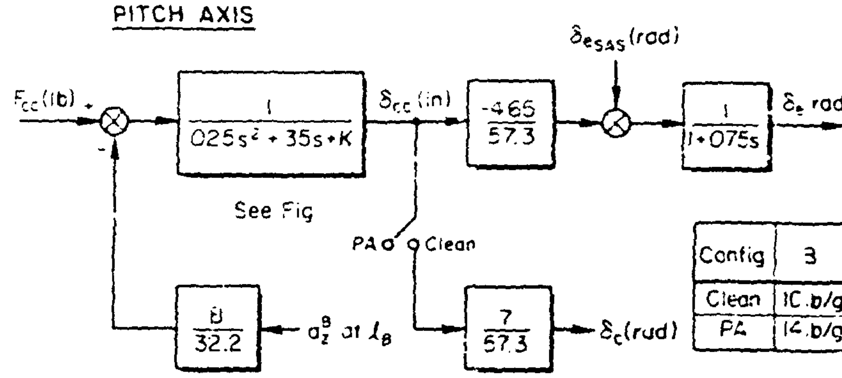


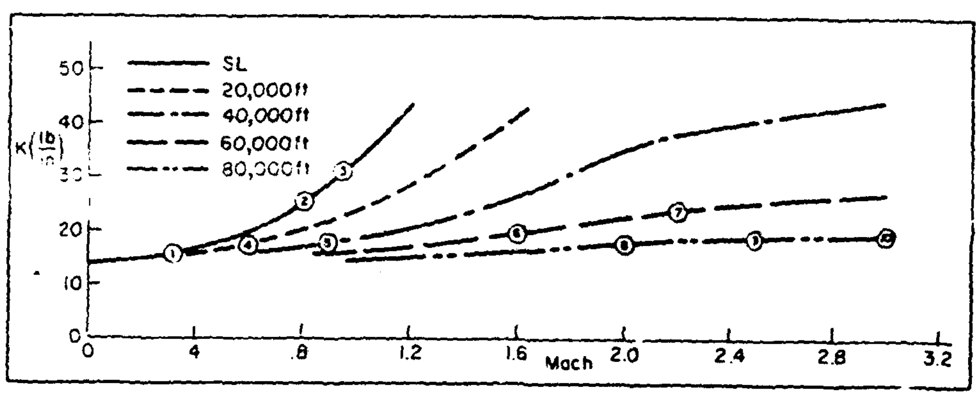
Figure XI-2. XB-70A General Arrangement

XB-70A

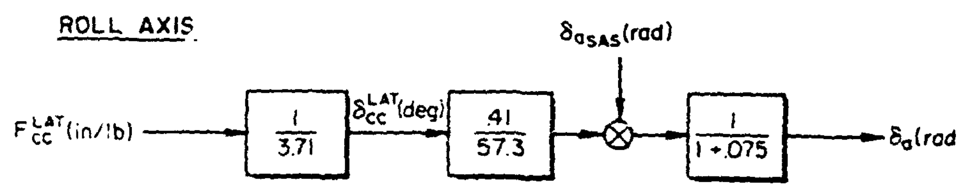
PITCH AXIS



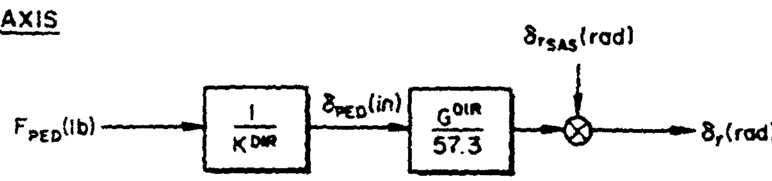
Config	B	Effective Bobweight FS	ℓ_B
Clean	10 lb/g	1852.2	-21.69ft
PA	14 lb/g	1479.2	10.96ft



ROLL AXIS



YAW AXIS



Config.	K^{DIR}	G^{DIR}
Gear UP	28 lb/in	.96 deg/in
Gear DN	31 lb/in	4.0 deg/in

Figure XI-5. XB-70A Control System

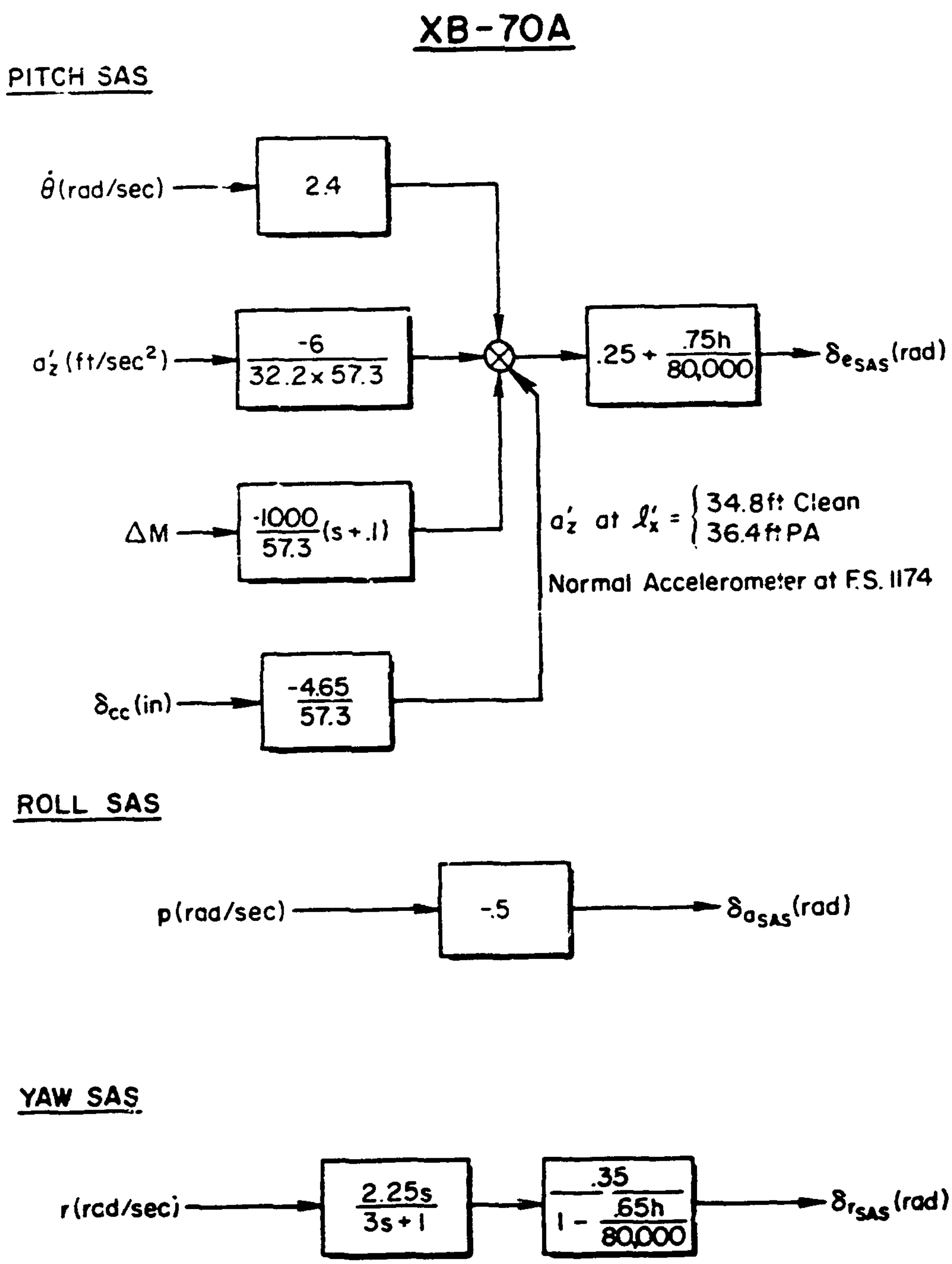


Figure XI-4. XB-70A SAS

TABLE XI-1

<u>XB-70A</u>

Power Approach Nondimensional Stability Derivatives

h = sea level

V_{T_o} = 347 ft/sec = 205 kt

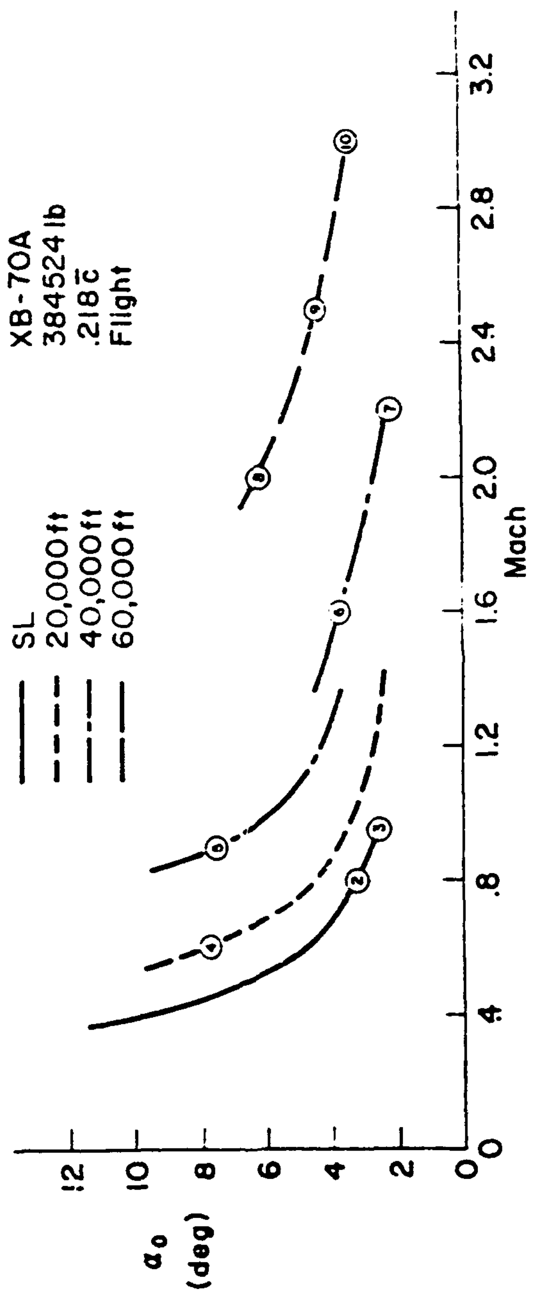
α_o = 7.5 deg

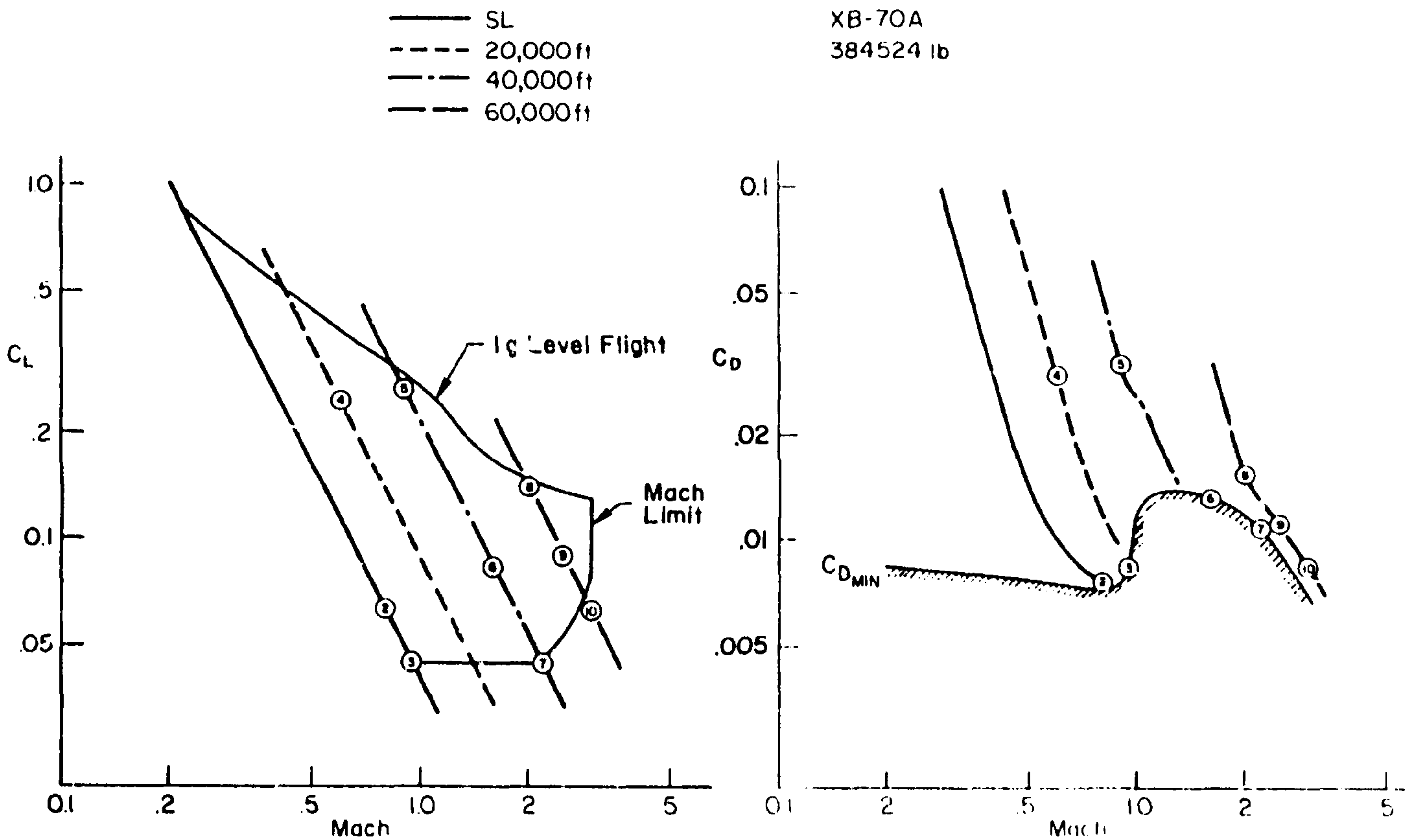
Longitudinal

C_L	=	.333
C_D	=	.0[illegible]
C_{L_α}	=	2.6/rad
C_{D_α}	=	.56/rad
C_{m_α}	=	−.23/rad
$C_{m_{\dot{\alpha}}}$	=	+.05/rad
C_{m_q}	=	−1.5/rad
$C_{L_{\delta_e}}$	=	.46/rad
$C_{m_{\delta_e}}$	=	−.19/rad

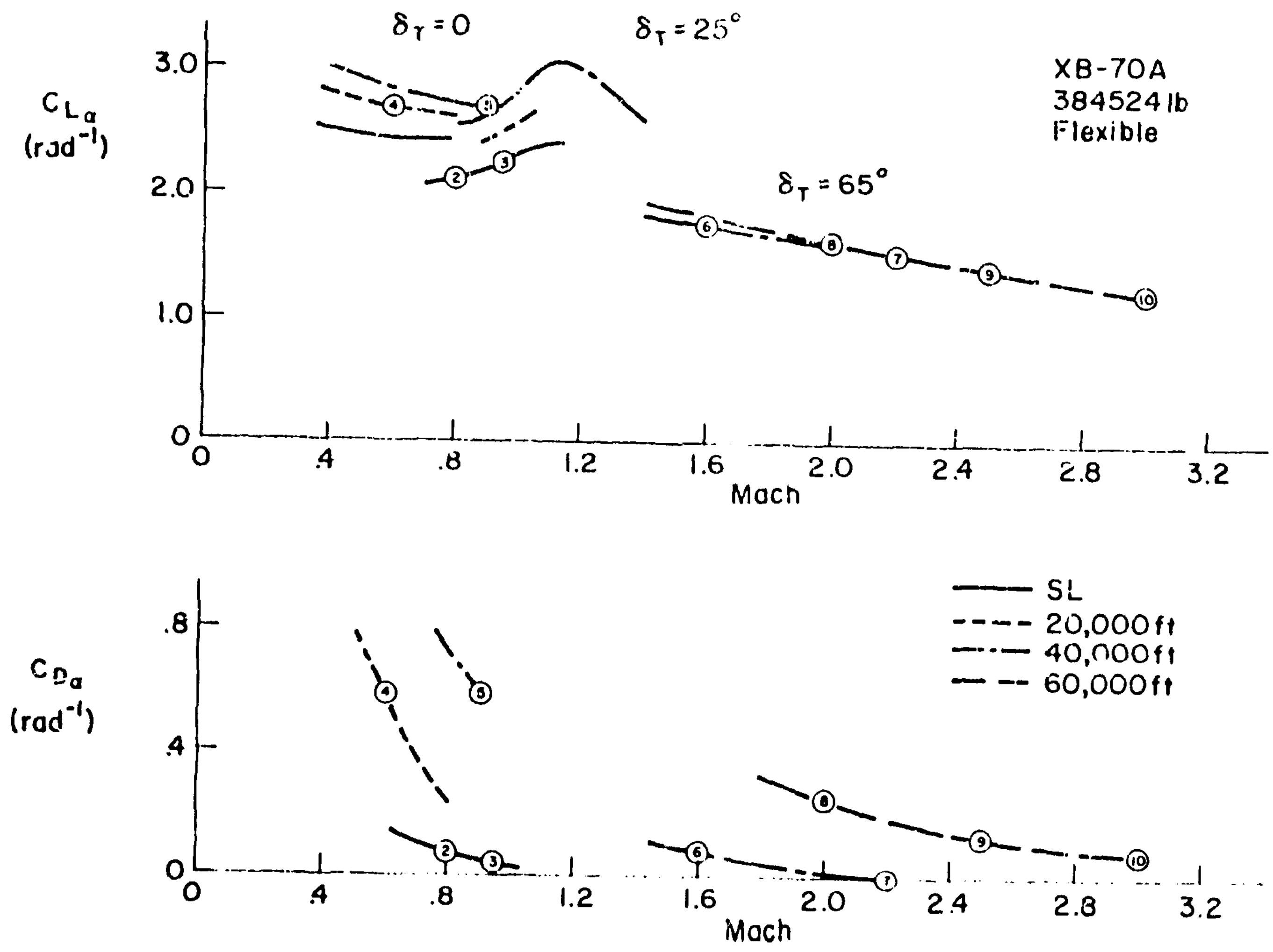
Lateral-Directional (Body Axis)

C_{y_β}	=	−.183/rad
C_{n_β}	=	.132/rad
C_{ℓ_β}	=	−.072/rad
C_{ℓ_p}	=	−.18/rad
C_{n_p}	=	−.26/rad
C_{ℓ_r}	=	−.03/rad
C_{n_r}	=	−.25/rad
$C_{y_{\delta_a}}$	=	−.063/rad
$C_{\ell_{\delta_a}}$	=	.042/rad
$C_{n_{\delta_a}}$	=	−.0052/rad
$C_{y_{\delta_r}}$	=	.12/rad
$C_{\ell_{\delta_r}}$	=	−.0018/rad
$C_{n_{\delta_r}}$	=	−.103/rad

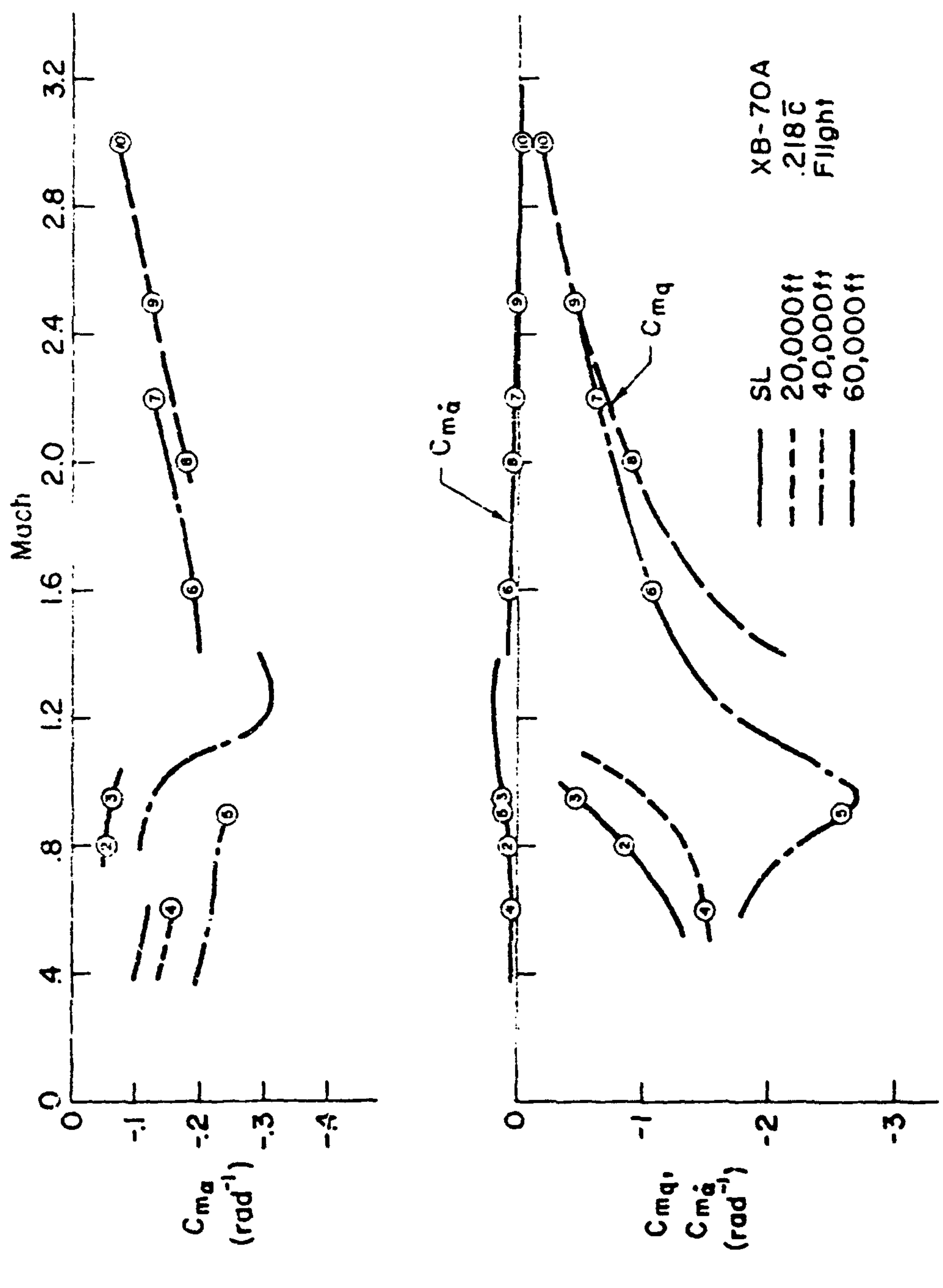

XB-70A
384524 lb
.218$\bar{c}$
Flight
SL
20,000 ft
40,000 ft
60,000 ft
α_0 (deg)
Mach



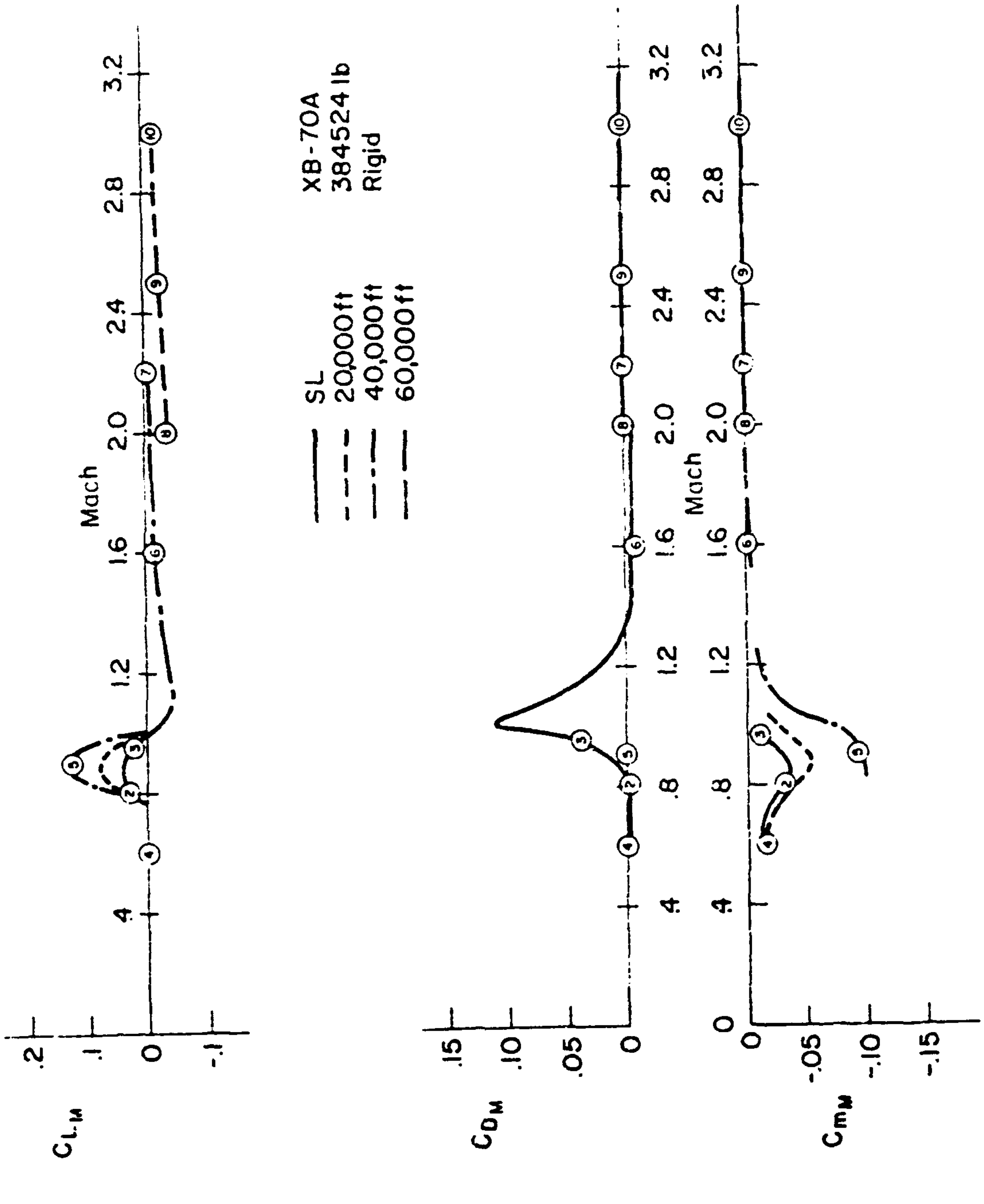
SL
20,000 ft
40,000 ft
60,000 ft
XB-70A
384524 lb
C_L
1g Level Flight
Mach Limit
Mach
C_D
$C_{D_{MIN}}$
Mach



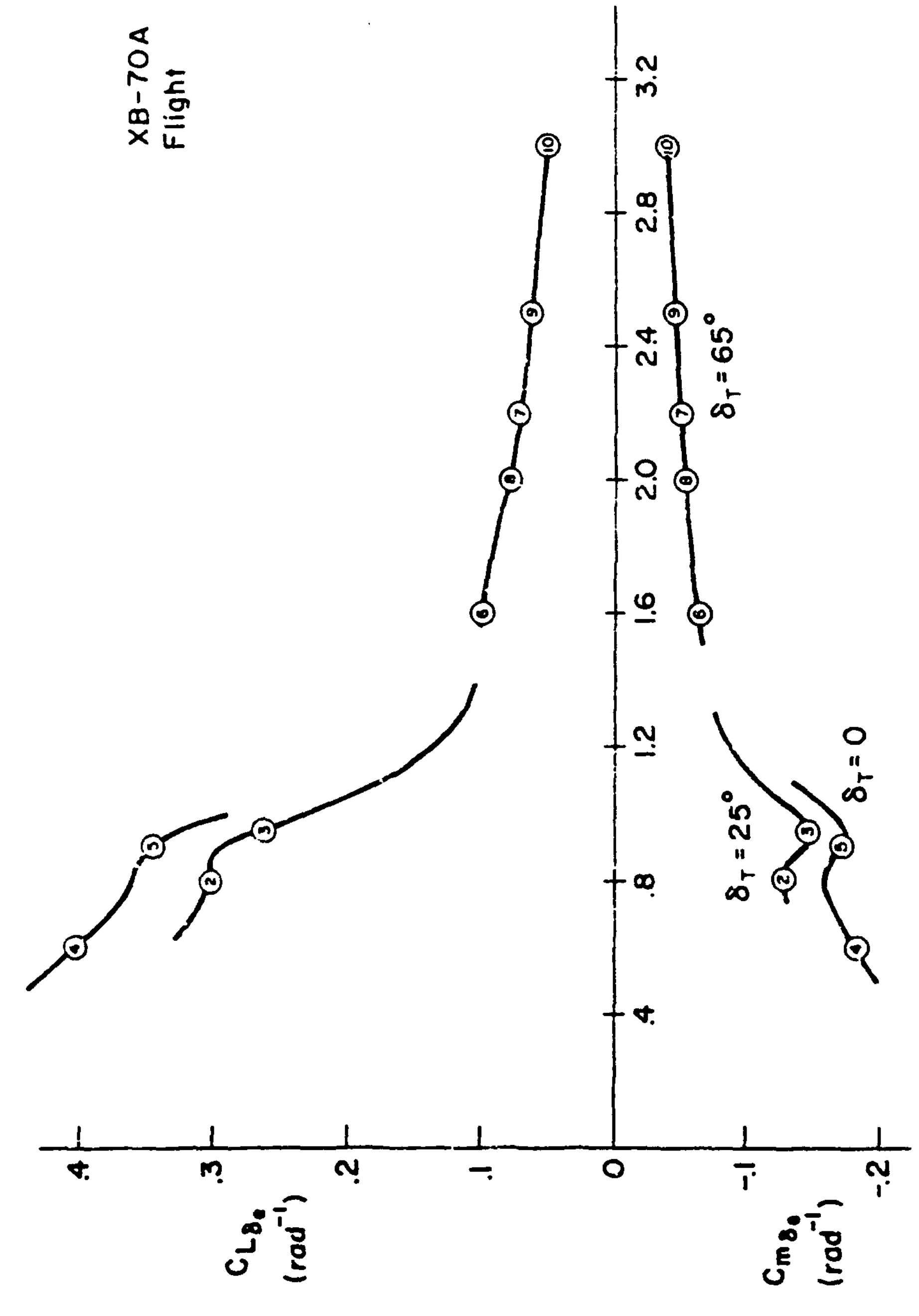
$\delta_T = 0$
$\delta_T = 25°$
$\delta_T = 65°$
XB-70A
384524 lb
Flexible
C_{L_α} (rad^{-1})
3.0
2.0
1.0
0
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
Mach
SL
20,000 ft
40,000 ft
60,000 ft
C_{D_α} (rad^{-1})
.8
.4
0
Mach



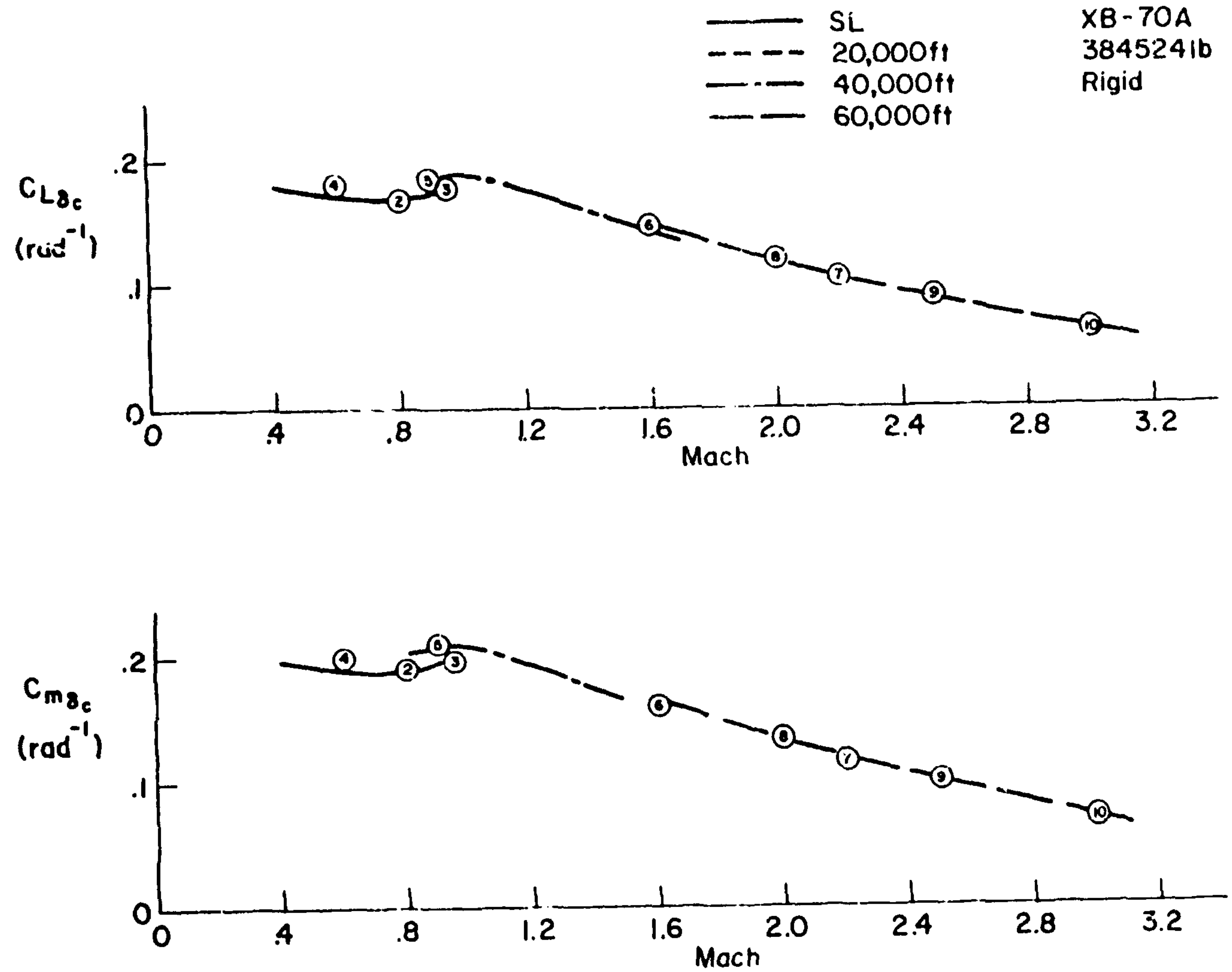
Mach
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
Cmα (rad⁻¹)
0
-.1
-.2
-.3
-.4
Cmq, Cmα̇ (rad⁻¹)
0
-1
-2
-3
Cmα̇
Cmq
SL
20,000ft
40,000ft
60,000ft
XB-70A
.218c̄
Flight

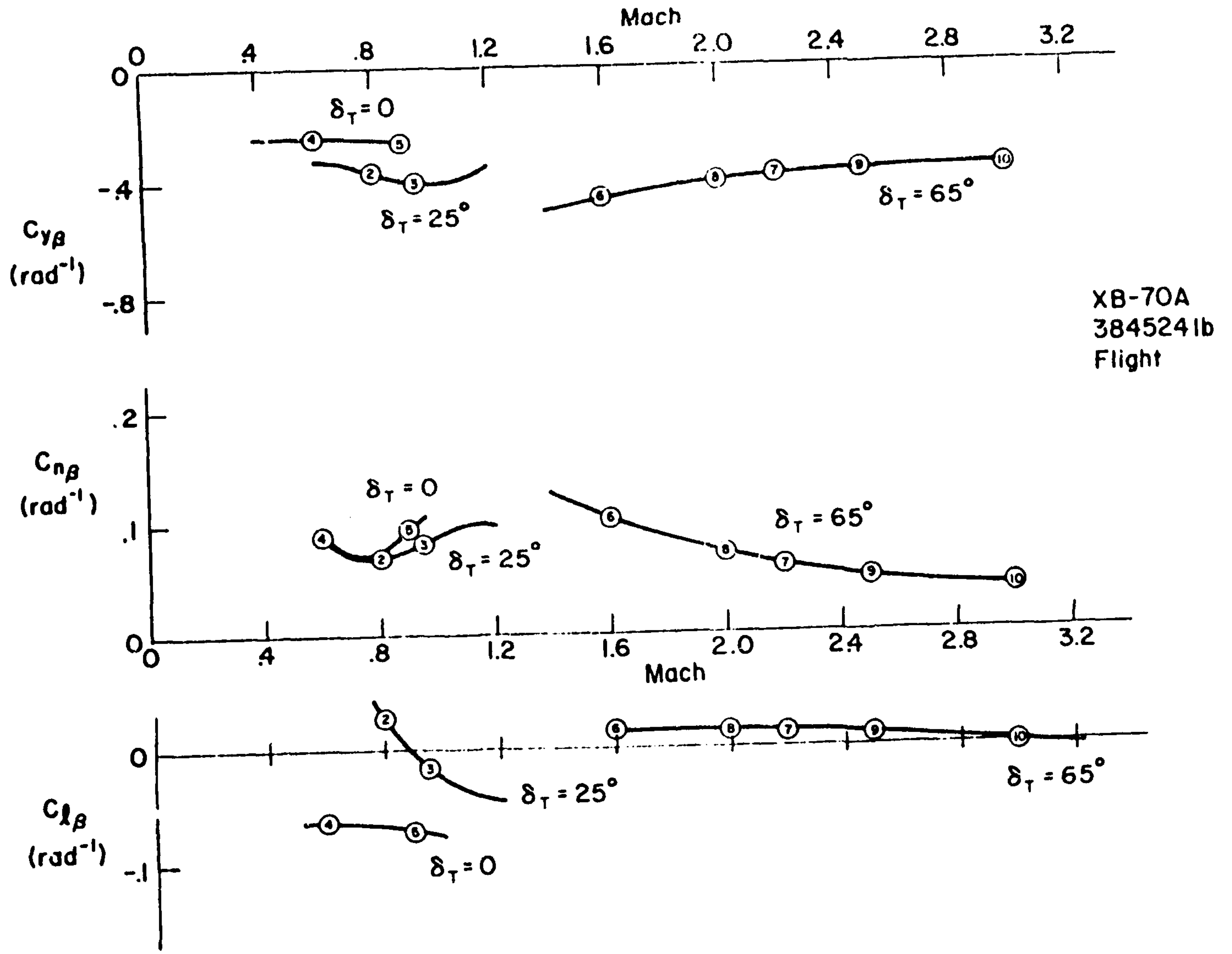


C_{L_M}
C_{D_M}
C_{m_M}
Mach
SL
20,000 ft
40,000 ft
60,000 ft
XB-70A
384524 lb
Rigid

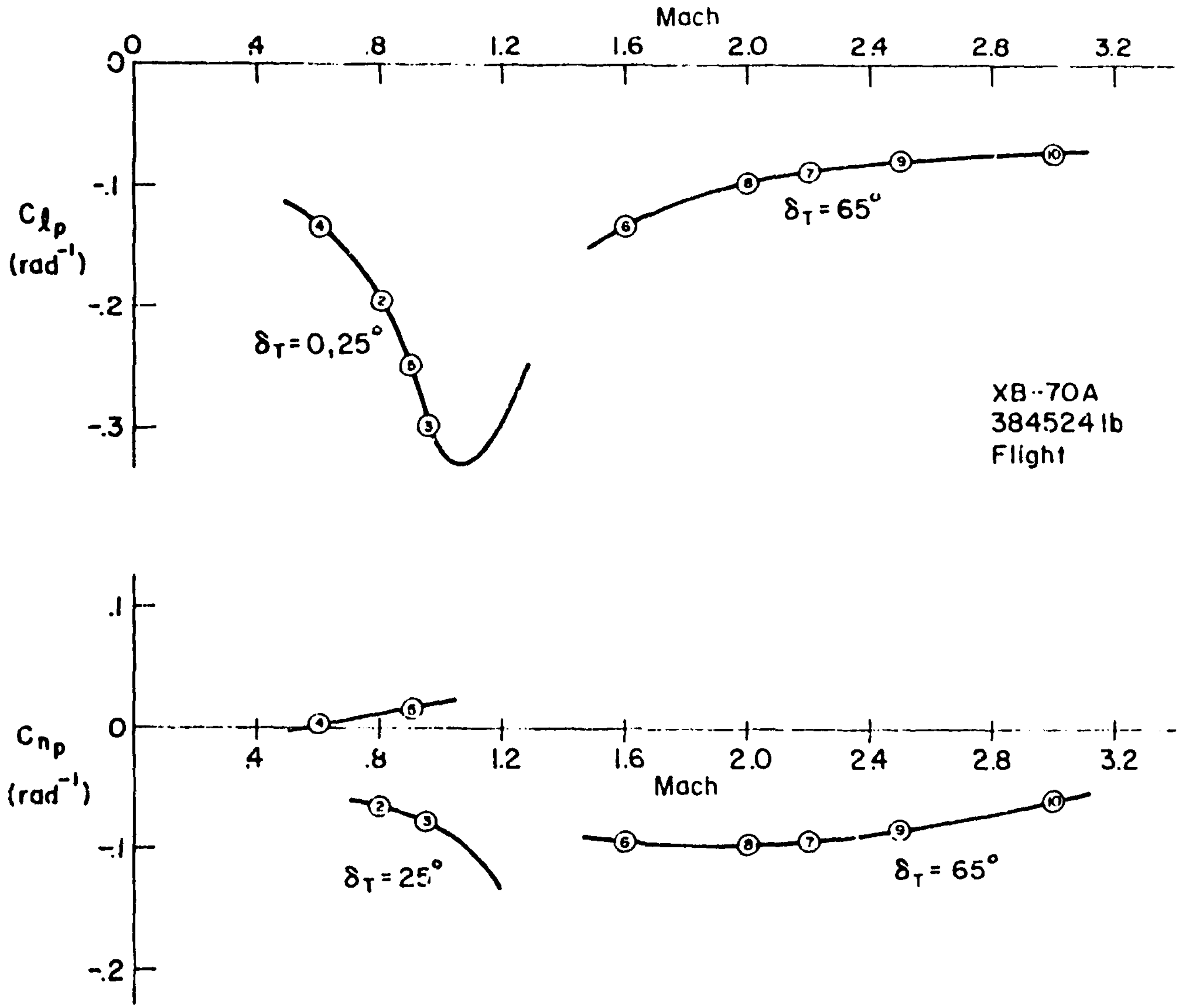


XB-70A
Flight
$C_{L_{\delta_e}}$
(rad^{-1})
$C_{m_{\delta_e}}$
(rad^{-1})
.4
.3
.2
.1
0
-.1
-.2
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
$\delta_T = 65°$
$\delta_T = 25°$
$\delta_T = 0$

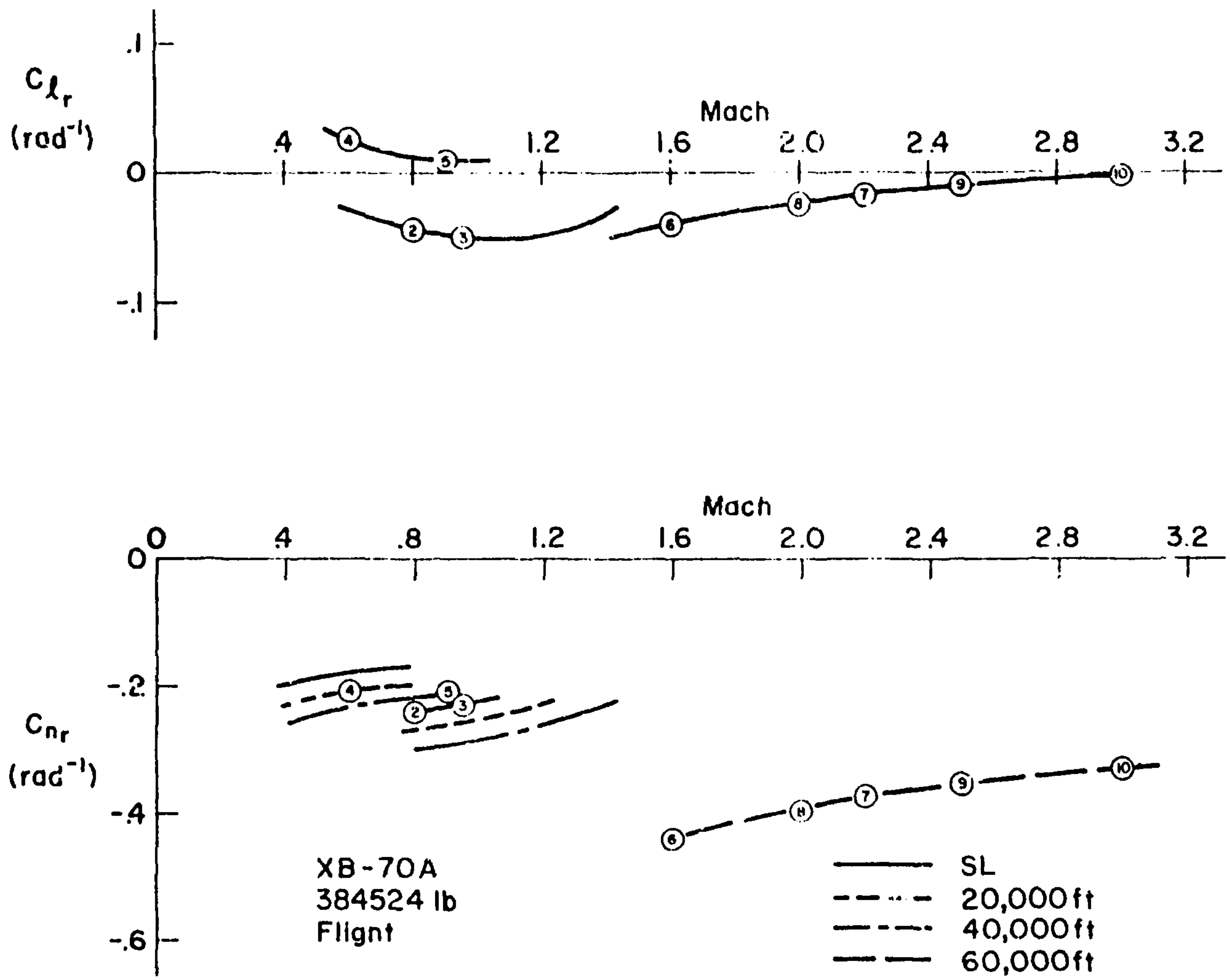

SL
20,000ft
40,000ft
60,000ft
XB-70A
384524lb
Rigid
$C_{L_{\delta_c}}$ (rad^{-1})
$C_{m_{\delta_c}}$ (rad^{-1})
Mach



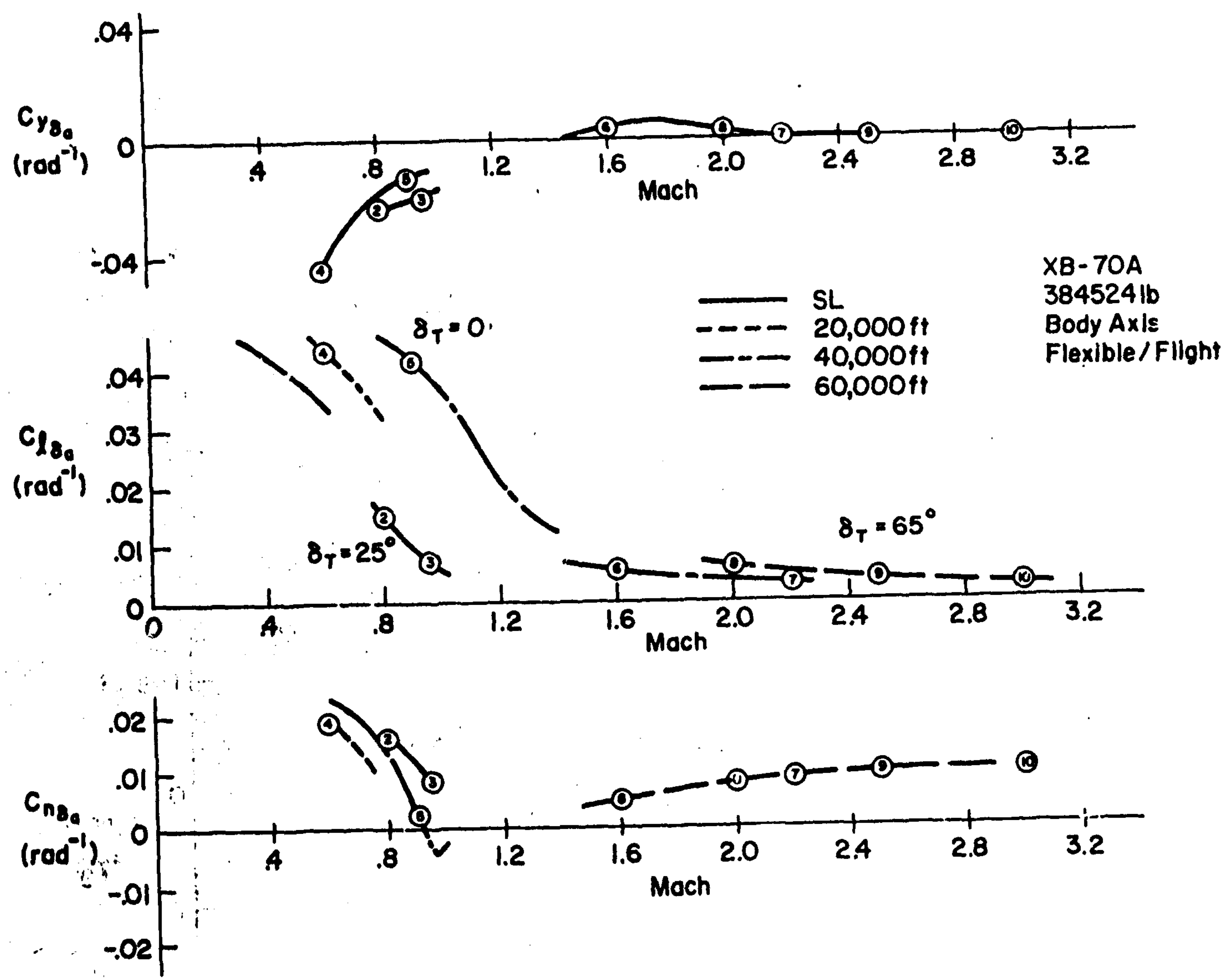
Mach
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
0
-.4
-.8
C_{y_β} (rad^{-1})
$\delta_T = 0$
$\delta_T = 25°$
$\delta_T = 65°$
XB-70A
384524 lb
Flight
.2
.1
0
C_{n_β} (rad^{-1})
$\delta_T = 0$
$\delta_T = 25°$
$\delta_T = 65°$
Mach
0
-.1
C_{l_β} (rad^{-1})
$\delta_T = 25°$
$\delta_T = 0$
$\delta_T = 65°$



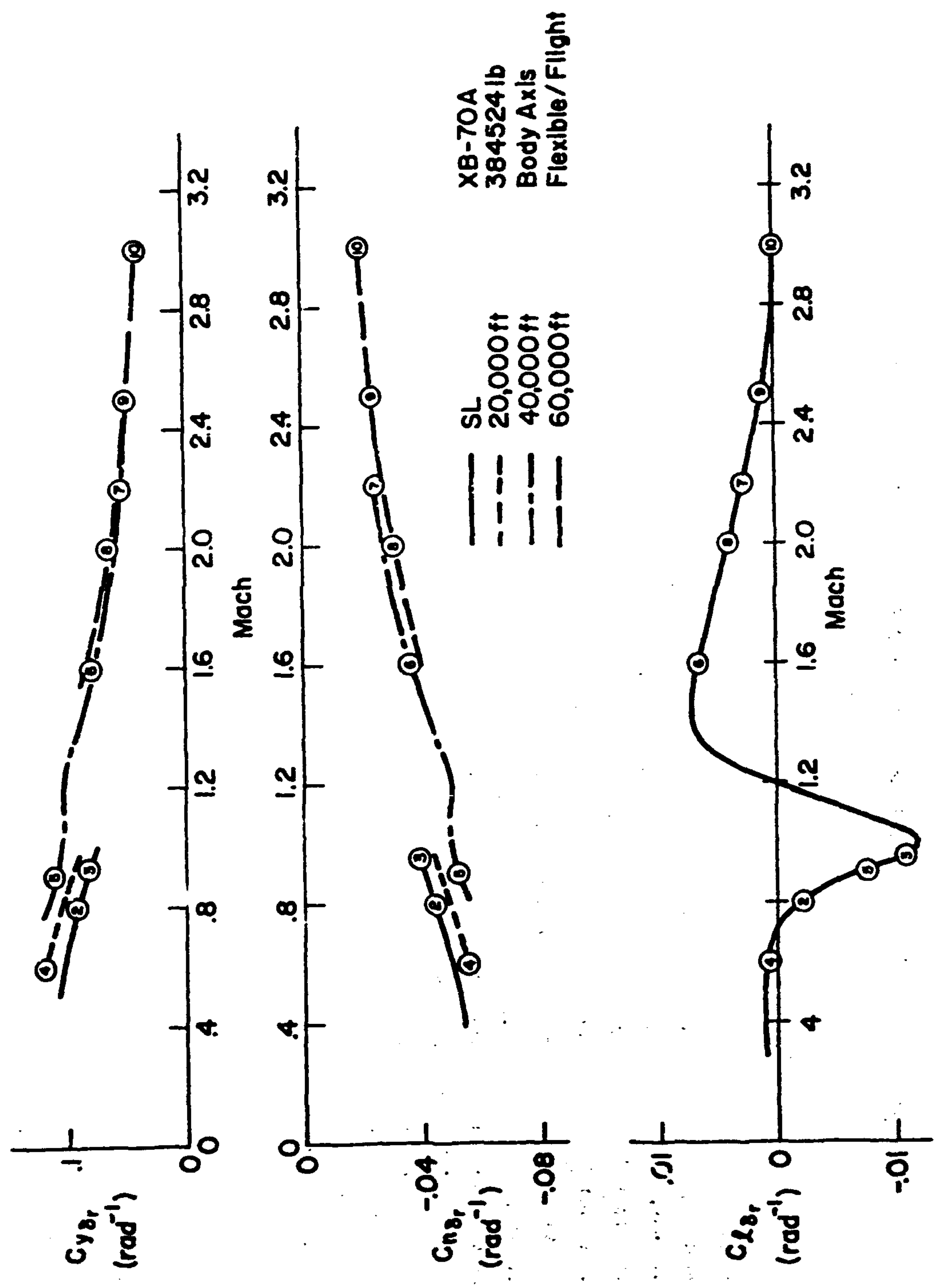
Mach
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
C_{ℓ_p} (rad^{-1})
-.1
-.2
-.3
$\delta_T = 65°$
$\delta_T = 0,25°$
XB-70A
384524 lb
Flight
C_{n_p} (rad^{-1})
.1
0
-.1
-.2
$\delta_T = 25°$
$\delta_T = 65°$



C_{ℓ_r} (rad^{-1})
.1
0
-.1
Mach
.4
1.2
1.6
2.0
2.4
2.8
3.2
C_{n_r} (rad^{-1})
0
-.2
-.4
-.6
Mach
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
XB-70A
384524 lb
Flight
SL
20,000ft
40,000ft
60,000ft



$C_{y_{\delta_a}}$ (rad^{-1})
$C_{l_{\delta_a}}$ (rad^{-1})
$C_{n_{\delta_a}}$ (rad^{-1})
Mach
$\delta_T = 0$
$\delta_T = 25°$
$\delta_T = 65°$
SL
20,000 ft
40,000 ft
60,000 ft
XB-70A
384524 lb
Body Axis
Flexible/Flight



XB-70A
384524 lb
Body Axis
Flexible/Flight
SL
20,000 ft
40,000 ft
60,000 ft
$C_{y_{\delta_r}}$ (rad^{-1})
$C_{n_{\delta_r}}$ (rad^{-1})
$C_{\ell_{\delta_r}}$ (rad^{-1})
Mach

TABLE XI-2

XB-70A DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

$s = 6297.8$ sq ft, $b = 105.0$ ft, $\bar{c} = 78.53$ ft

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M(-)	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
VTO(FPS)	346.	893.	1060.	622.	871.	1548.	2129.	1936.	2420.	2904.
VTO(KTAS)	205.	529.	628.	369.	516.	918.	1261.	1147.	1433.	1720.
VTO(KCAS)	205.	529.	628.	275.	278.	521.	710.	432.	535.	630.
W(LBS)	300017.	384546.	384546.	384546.	384546.	384546.	384546.	384546.	384546.	384546.
C.G.(MGC)	.235	.218	.218	.218	.218	.218	.218	.218	.218	.218
IX (SLUG-FT SQ)	.145E+7	.180E+7	.180E+7	.180E+7	.180E+7	.180E+7	.180E+7	.180E+7	.180E+7	.180E+7
IY (SLUG-FT SQ)	.160E+8	.100E+8	.100E+8	.100E+8	.100E+8	.100E+8	.100E+8	.100E+8	.100E+8	.100E+8
IZ (SLUG-FT SQ)	.172E+8	.221E+8	.221E+8	.221E+8	.221E+8	.221E+8	.221E+8	.221E+8	.221E+8	.221E+8
IXZ(SLUG-FT SQ)	-600035.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.
EPSILON(DEG)	2.18	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Q(PSF)	142.	948.	1336.	245.	224.	707.	1335.	424.	663.	954.
QC(PSF)	146.	1109.	1666.	268.	273.	1105.	2253.	703.	1139.	1675.
ALPHA(DEG)	7.50	3.20	2.60	7.70	7.50	3.70	2.30	6.20	4.40	3.40
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	99.0	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7
LZP(FT)	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70
ITH(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LTH(FT)	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20

TABLE XI-3

XB-70A LONGITUDINAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
XU *	-.0105	-.00514	-.0352	.000472	.00212	-.00221	-.00780	-.00166	-.00267	-.00285
ZU *	-.0893	-.0188	-.00588	-.0271	-.0399	-.00543	-.00141	-.00494	-.00149	.00135
MU *	.000343	-.00113	-.000452	.000199	-.000644	.796E-4	.000143	.000152	.486E-4	-.376E-4
XW	.0327	.0629	.0698	.00819	.00700	.0282	.0349	.00776	.00969	.00983
ZW	-.757	-1.19	-1.50	-.580	-.380	-.424	-.515	-.192	-.204	-.218
MW	-.00290	-.00285	-.00376	-.00302	-.00316	-.00429	-.00403	-.00189	-.00163	-.00114
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	.715E-4	.000161	.000277	.610E-4	.567E-4	.285E-4	.114E-4	.655E-5	0.	0.
MQ	-.749	-1.75	-1.10	-1.13	-1.30	-.930	-.731	-.383	-.213	-.128
XDE	8.77	7.67	7.61	6.55	4.87	1.87	1.93	1.90	1.26	1.22
ZDE	-43.8	-137.	-168.	-48.4	-37.0	-29.0	-38.0	-13.8	-16.4	-20.6
MDE	-.836	-7.46	-11.9	-2.61	-2.24	-3.11	-4.62	-1.61	-2.06	-2.45
XDES	5.77	8.37	8.44	7.01	5.30	2.40	1.98	1.93	1.61	1.49
ZDES	-43.8	-150.	-186.	-51.9	-40.3	-37.2	-49.2	-17.8	-20.9	-25.1
MDES	-.836	-6.10	-9.92	-2.24	-1.90	-2.27	-3.50	-1.20	-1.57	-1.98
XDTH	.000107	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4
ZDTH	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MDTH	.138E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6

TABLE XI-4

XB-70A ELEVATOR TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5
H	SL	SL	SL	20 K	40 K
M	.310	.800	.950	.6CC	.900
DENOMINATOR					
1/T(DET)1	(.0652)	-.0942	-.0470	(.0136)	.0278
1/T(DET)2	(.103)	.0960	.0806	(.0499)	-.0430
Z(DET)1	.591	.654	.487	.526	.460
W(DET)1	1.25	2.14	2.37	1.59	1.78
NUMERATORS					
N(U /DE)					
A(U)	5.77	7.67	7.61	6.55	4.87
1/T(U)1	6.60	49.6	75.7	.386	.289
Z(U)1	.922	.494	.314	(.508)	(.322)
W(U)1	.692	.848	.982	(34.0)	(93.4)
N(W /DE)					
A(W)	-43.8	-137.	-168.	-48.4	-37.0
1/T(W)1	7.30	-.00705	-.00175	34.4	53.7
1/T(W)2	(.0931)	.0113	.0358	(- .0460)	(-.0251)
1/T(W)3	(.0941)	50.2	76.4	(.0394)	(.0326)
N(THE/DE)					
A(THE)	-.839	-7.48	-11.9	-2.61	-2.25
1/T(THE)1	.0104	.00613	.0354	-.000936	-.000709
1/T(THE)2	.601	1.14	1.44	.523	.328
N(HD /DE)					
A(HD)	44.2	137.	168.	48.5	37.3
1/T(HD)1	-.0186	.00425	.0341	-.0111	-.00902
1/T(HD)2	-1.59	-6.67	-10.0	-3.59	-3.50
1/T(HD)3	2.37	8.28	10.9	4.71	4.76
N(AZP/DE)					
A(AZP)	39.2	593.	000.	207.	182.
1/T(AZP)1	.00537	-.00209	-.00138	-.000633	-.000407
1/T(AZP)2	-.0242	.00626	.0354	-.0104	-.00857
Z(AZP)1	.115	.144	.191	.0091	.0401
W(AZP)1	2.08	3.57	4.27	2.01	1.86

F/C #	6	7	8	9	10
H	[illegible] K	[illegible] K	[illegible] K	[illegible] K	[illegible] K
M	1.60	2.2[illegible]	2.0[illegible]	2.5[illegible]	[illegible]
DENOMINATOR					
1/T(DET)1	(.0494)	(.217)	(.0743)	(.118)	[illegible]
1/T(DET)2	(.0141)	(.0157)	(.0191)	(.00094)	.0[illegible]
Z(DET)1	.247	.206	.145	.1[illegible]	[illegible]
W(DET)1	2.65	2.9[illegible]	1.93	1.[illegible]	1.[illegible]
NUMERATORS					
N(U /DE)					
A(U)	1.87	1.53	1.[illegible]	1.26	1.22
1/T(U)1	165.	259.	224.	305.	346.
Z(U)1	.437	.0234	.[illegible]	.[illegible]	.[illegible]
W(U)1	.392	.426	.1[illegible]	.1[illegible]	.1[illegible]
N(W /DE)					
A(W)	-29.0	-38.0	-13.8	-16.4	-2[illegible]
1/T(W)1	167.	260.	226.	305.	[illegible]
1/T(W)2	(.0368)	(.62[illegible])	(.0[illegible])	(.1[illegible])	[illegible]
1/T(W)3	(.0112)	(.005[illegible])	(.0100)	(.00477)	346.
N(THE/DE)					
A(THE)	-3.11	-4.52	-1.[illegible]2	-2.[illegible]	-2.45
1/T(THE)1	.00258	.00793	.00174	.00273	.00[illegible]
1/T(THE)2	.384	.487	.175	.191	.[illegible]
N(HD /DE)					
A(HD)	29.0	38.0	13.9	16.4	20.[illegible]
1/T(HD)1	.000906	.00725	-.00[illegible]634	.001[illegible]	.00223
1/T(HD)2	-7.55	-10.[illegible]	-[illegible]	-7.51	-8.42
1/T(HD)3	8.43	11.[illegible]	6.45	7.73	[illegible]
N(AZP/DE)					
A(AZP)	275.	414.	144.	185.	[illegible]
1/T(AZP)1	-.00147	-.000513	.00147	-.[illegible]	-.000[illegible]
1/T(AZP)2	.00236	.00785	-.00214	.00264	.00[illegible]
Z(AZP)1	.0642	.0697	.[illegible]	.[illegible]	.[illegible]
W(AZP)1	2.59	3.39	1.[illegible]	2.27	[illegible]

TABLE XI-5

XB-70A THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Open

(BODY AXIS SYST:M)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	60 K	40 K	60 K	60 K	40 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	(.0652)	-.0942	-.0470	(.0136)	.0278	(.0494)	(.217)	(.0743)	(.118)	-.00001
1/T(DET)2	(.103)	.0960	.0804	(.0499)	-.0430	(.0161)	(.0157)	(.0181)	(.00286)	.0107
Z(DET)1	.591	.654	.487	.526	.460	.747	.266	.145	.194	.0050
W(DET)1	1.25	2.14	2.37	1.59	1.78	2.65	2.00	1.03	1.00	1.03
NUMERATORS										
N(U /DTH)										
A(U)	.000107	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4
1/T(U)1	-.0283	-.0231	-.0236	-.0262	-.0149	-.00546	-.00566	-.00640	-.00856	-.00646
Z(U)1	.586	.629	.465	.482	.384	.200	.168	.00604	-.0168	-.0301
W(U)1	1.24	2.14	2.37	1.54	1.75	2.64	2.99	1.80	1.06	1.90
N(W /DTH)										
A(W)	.372E-4	.000194	.000231	.000133	.000186	.000339	.000658	.000423	.000571	.000678
1/T(W)1	.0689	-.00352	-.00267	(.902)	-.0103	.00248	-.000257	-.000435	-.850E-4	.000560
1/T(W)2	.0901	-.439	-.138	(.0299)	-.265	.0279	.0615	.0584	.0203	-.0128
N(THE/DTH)										
A(THE)	.136E-6	.219E-6	.219E-6	.219E-6	.219E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6
1/T(THE)1	(.798)	-.411	-.132	.149	-.158	.0571	.0473	.0977	.0264	-.0140
1/T(THE)2	(.647)	1.18	1.49	.506	.290	.399	.510	.156	.196	.221
N(HD /DTH)										
A(HD)	.140E-4	.467E-5	.380E-5	.112E-4	.109E-4	.540E-5	.336E-5	.304E-5	.642E-5	.406E-5
1/T(HD)1	.344	-.364	-.125	.0558	-.0880	.0411	.0584	.0541	.0190	-.0133
Z(HD)1	.459	.233	.130	.290	.316	.116	.0555	.0777	.0456	.0300
W(HD)1	1.98	7.50	9.89	3.08	3.19	5.81	8.90	3.56	4.57	5.60
N(AZP/DTH)										
A(AZP)	-.135E-4	-.214E-4	-.214E-4	-.214E-4	-.214E-4	-.215E-4	-.215E-4	-.215E-4	-.215E-4	-.215E-4
1/T(AZP)1	-.0124	-.00201	-.00138	-.00711	-.00471	-.00135	-.000528	-.00182	-.00103	-.000662
1/T(AZP)2	.492	-.402	-.131	.125	-.119	.0534	.0653	.0770	.0257	-.0141
Z(AZP)1	.359	.187	.183	.156	.110	.0821	.0772	.0509	.0466	.0425
W(AZP)1	1.71	3.32	4.04	1.94	1.97	2.59	3.35	1.94	2.25	2.54

TABLE XI-6

XB-70A STICK FORCE TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Closed)

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5
H	SL	SL	SL	20 K	40 K
M	.310	.800	.950	.600	.900
DENOMINATOR					
1/T(DET)1	14.5	-.0579	-.0201	11.2	.0243
1/T(DET)2	(.0474)	.0596	.0536	(-.0275)	-.0383
1/T(DET)3	(.0919)	10.0	10.5	(.0409)	11.6
Z(DET)1	.514	.229	.0150	.383	.373
W(DET)1	1.34	3.97	5.05	2.12	2.15
Z(DET)2	.255	.284	.267	.310	.296
W(DET)2	25.3	32.2	35.6	26.2	26.6
NUMERATORS					
N(U /FST)					
A(U)	-290.	-332.	-329.	-283.	-211.
1/T(U)1	6.50	49.6	75.7	.386	.280
Z(U)1	.522	.404	.314	(.508)	(.322)
W(U)1	.652	.848	.982	(34.0)	(53.4)
N(W /FST)					
A(W)	1897.	5937.	7250.	2095.	1602.
1/T(W)1	7.30	-.00705	-.00178	34.4	53.7
1/T(W)2	(.0531)	.0113	.0358	(-.0460)	(-.0251)
1/T(W)3	(.0941)	50.2	76.4	(.0394)	(.0325)
N(THE/FST)					
A(THE)	36.3	324.	517.	113.	97.2
1/T(THE)1	.0104	.00612	.0354	-.000936	-.000709
1/T(THE)2	.601	1.14	1.44	.523	.328
N(HD /FST)					
A(HD)	-1913.	-5546.	-7257.	-2114.	-1616.
1/T(HD)1	-.0106	.00425	.0341	-.0111	-.00902
1/T(HD)2	-1.50	-6.67	-10.0	-3.59	-3.50
1/T(HD)3	2.37	8.28	10.9	4.71	4.76
N(AZP/FST)					
A(AZP)	-1497.	-25684.	-43278.	-8945.	-7897.
1/T(AZP)1	.00537	-.00201	-.00136	-.000633	-.000407
1/T(AZP)2	-.0242	.00426	.0594	-.0104	-.00857
Z(AZP)1	.115	.144	.101	.0951	.0491
W(AZP)1	2.09	3.57	4.27	2.01	1.36

F/C #	6	7	8	9	10
H	40 K	40 K	60 K	[illegible]	[illegible]
M	1.60	2.20	2.00	2.5[illegible]	3.0[illegible]
DENOMINATOR					
1/T(DET)1	11.8	11.9	12.4	12.3	-.00[illegible]
1/T(DET)2	(.0516)	(.272)	(.0446)	(.1261)	.00[illegible]
1/T(DET)3	(.0139)	(.0134)	(.0165)	(.0[illegible])	12.[illegible]
Z(DET)1	.157	.0747	.107	[illegible]	.024[illegible]
W(DET)1	3.25	3.[illegible]	2.20	2.3[illegible]	[illegible]
Z(DET)2	.282	.259	.281	.274	.274
W(DET)2	28.9	31.1	24.5	2[illegible].4	29.0
NUMERATORS					
N(U /FST)					
A(U)	-81.1	-66.9	-64.8	-54.5	-52.[illegible]
1/T(U)1	165.	259.	226.	308.	355.
Z(U)1	.637	.0236	.822	.600	.6[illegible]8
W(U)1	.352	.425	.164	.182	.197
N(W /FST)					
A(W)	1754.	1543.	564.	709.	881.
1/T(W)1	167.	760.	226.	355.	-.00250
1/T(W)2	(.0548)	(.670)	(.0106)	(.187)	.00060
1/T(W)3	(.0112)	(.70595)	(.312[illegible])	(.00472)	345.
N(THE/FST)					
A(THE)	135.	200.	69.9	83.4	106.
1/T(THE)1	.00259	.00773	.00174	.00277	.00270
1/T(THE)2	.384	.482	.175	.191	.208
N(HD /FST)					
A(HD)	-1256.	-1665.	-593.	-710.	-893.
1/T(HD)1	.000906	.00726	-.000424	.00149	.00223
1/T(HD)2	-7.59	-10.8	-6.09	-7.61	-8.47
1/T(HD)3	8.43	11.5	6.45	7.73	8.55
N(AZP/FST)					
A(AZP)	-11900.	-17913.	-6239.	-9022.	-9464.
1/T(AZP)1	-.00147	-.000513	.00167	-.00106	-.000442
1/T(AZP)2	.00236	.00785	-.00214	.00244	.00[illegible]84
Z(AZP)1	.0547	.0692	.0410	.0420	.0416
W(AZP)1	2.59	3.39	1.06	2.27	2.60

TABLE XI-7

XB-70A THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	14.5	-.0579	-.0201	11.2	.0243	11.8	11.9	12.4	12.3	-.00698
1/T(DET)2	(.0474)	.0596	.0536	(-.0275)	-.0383	(.0516)	(.272)	(.0664)	(.126)	.00884
1/T(DET)3	(.0919)	10.0	10.5	(.0405)	11.6	(.0139)	(.0134)	(.0165)	(.00855)	12.2
Z(DET)1	.514	.229	.0150	.383	.373	.157	.0762	.107	.0554	.0241
W(DET)1	1.34	3.97	5.05	2.12	2.15	3.25	3.05	2.20	2.30	2.29
Z(DET)2	.255	.284	.267	.310	.296	.282	.259	.281	.274	.274
W(DET)2	25.3	32.2	35.6	26.2	26.6	28.0	31.1	26.6	27.6	28.0
NUMERATORS										
N(U /DTH)										
A(U)	.000107	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4
1/T(U)1	-.0251	-.0101	-.00750	-.0155	-.0125	-.00515	-.00373	-.00557	-.00462	-.00426
1/T(U)2	14.5	10.1	10.5	11.2	11.7	11.9	11.9	12.5	12.4	12.2
Z(U)1	.508	.212	.00227	.338	.301	.115	.0462	-.0223	-.0522	-.0759
W(U)1	1.33	3.96	5.04	2.07	2.13	3.23	3.96	2.15	2.24	2.36
Z(U)2	.255	.284	.267	.310	.296	.282	.259	.281	.274	.274
W(U)2	25.3	32.2	35.6	26.2	26.6	28.0	31.1	26.6	27.6	28.0
N(W /DTH)										
A(W)	.372E-4	.000194	.000231	.000133	.000186	.000339	.000458	.000423	.000531	.000628
1/T(W)1	18.9	-.00393	-.00264	12.0	-.00963	.00517	-.000236	-.000292	.143E-4	.000780
1/T(W)2	(-.220)	-.500	-.164	(.118)	-.318	.0165	.0588	.0538	.0184	-.0113
1/T(W)3	(.101)	11.0	11.1	(.0362)	12.4	12.7	12.7	13.0	13.0	12.9
Z(W)1	.221	.250	.226	.290	.279	.260	.235	.262	.250	.257
W(W)1	19.5	32.8	36.0	26.6	26.8	28.0	31.1	26.7	27.6	28.0

TABLE XI-7 (Concl)

W(THE/GTH)										
A(THE)	.130E-6	.219E-6	.219E-6	.219E-6	.21	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6
1/T(THE)1	12.1	-.425	-.134	.165	-.1	.0584	.0573	.105	.0264	-.0140
1/T(THE)2	(.705)	1.34	1.75	.490	.2	.406	.523	.146	.222	.228
1/T(THE)3	(.678)	11.3	11.2	12.3	12	12.8	12.8	13.1	13.0	13.0
Z(THE)1	.302	.248	.225	.287	.2	.260	.235	.268	.250	.257
W(THE)1	25.4	32.0	35.2	26.1	26	27.9	31.0	26.6	27.6	27.9
W(HD/GTH)										
A(HD)	.149E-4	.467E-5	.380E-5	.112E-4	.16	.540E-5	.336E-5	.604E-5	.642E-5	.406E-5
1/T(HD)1	.310	-.324	-.109	.0770	-.0	.0383	.0549	.0508	.0187	-.0124
1/T(HD)2	15.7	9.66	10.5	10.8	11	11.7	11.8	12.4	12.2	12.1
Z(HD)1	.443	.0196	-.108	.222	.2	.0514	-.0219	.0519	.0104	-.0168
W(HD)1	1.91	4.06	11.6	3.63	3.	6.30	[illegible].75	3.81	4.00	6.04
Z(HD)2	.252	.314	.302	.319	.	.291	.276	.284	.270	.281
W(HD)2	24.4	32.6	36.2	26.2	26	28.1	31.2	26.6	27.6	28.0
W(AZP/GTH)										
A(AZP)	-.135E-4	-.214E-4	-.214E-4	-.214E-4	-.21	-.215E-4	-.215E-4	-.215E-4	-.215E-4	-.215E-4
1/T(AZP)1	-.0124	-.00201	-.00138	-.00711	-.00	-.00135	-.000528	-.00182	-.00103	-.000[illegible]
1/T(AZP)2	.491	-.403	-.131	.124	-.1	.0534	.0653	.0779	.0257	-.0141
1/T(AZP)3	13.3	11.1	11.1	12.1	12	12.7	12.7	13.0	13.0	12.9
Z(AZP)1	.367	.184	.165	.152	.	.0763	.0703	.0671	.0433	.0396
W(AZP)1	1.71	3.63	4.42	2.03	1.	2.65	3.43	1.97	2.28	2.50
Z(AZP)2	.277	.255	.231	.291	.2	.262	.237	.260	.260	.250
W(AZP)2	25.3	32.0	35.3	26.1	26	27.9	31.0	26.6	27.6	27.5

TABLE XI-8

XB-70A ELEVATOR TRANSFER FUNCTION FACTORS

SAS On — Bobweight Loop Open

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	50 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	13.3	13.3	13.3	13.3	1.48	13.3	13.3	1.54	1.52	1.45
1/T(DET)2	(.211)	(.575)	(.656)	(.390)	3.10	(.296)	(.317)	3.06	3.30	3.05
1/T(DET)3	(.101)	(.0533)	(.0722)	(.0726)	13.3	(.0496)	(.0542)	13.3	13.3	13.3
Z(DET)1	.687	.811	.735	.925	.404	.818	.796	.342	.256	.361
W(DET)1	1.41	3.09	3.78	2.10	.0501	2.79	3.23	.0394	.0407	.0436
Z(DET)2	.275	.222	.201	.272	.267	.253	.278	.265	.256	.252
W(DET)2	25.5	31.2	34.5	25.5	25.9	27.3	30.3	26.1	27.0	27.3
NUMERATORS										
N(U /DE)										
A(U)	5.26	3.29	1.99	3.84	2.51	.489	.136	.628	.471	.389
1/T(U)1	6.60	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
1/T(U)2	13.3	63.7	124.	37.4	62.5	359.	1320.	351.	541.	588.
Z(U)1	.922	.401	.313	.997	.988	.431	.0286	.821	.670	.897
W(U)1	.652	.875	1.02	.451	.307	.363	.442	.167	.186	.201
Z(U)2	.277	.226	.205	.273	.269	.256	.230	.264	.257	.253
W(U)2	25.3	31.9	35.1	26.1	26.5	27.7	30.8	26.5	27.4	27.8
N(W /DE)										
A(W)	-39.9	-58.8	-43.8	-20.4	-19.1	-7.51	-3.45	-5.77	-5.48	-6.56
1/T(W)1	7.30	.0245	-.0150	13.3	13.3	.0150	-.0167	.00865	-.0122	-.0125
1/T(W)2	13.3	-.0258	.0432	37.9	62.8	-.0178	.0222	-.0102	.0122	.0132
1/T(W)3	(.0531)	13.3	13.3	(-.111)	(-.104)	13.3	13.3	13.3	13.3	13.3
1/T(W)4	(.0941)	64.5	125.	(.0268)	(.0268)	362.	1303.	352.	542.	590.
Z(W)1	.277	.226	.205	.273	.269	.256	.230	.266	.257	.253
W(W)1	25.3	31.9	35.1	26.1	26.5	27.7	30.9	26.5	27.4	27.8

TABLE XI-8 (Concluded)

N(THE/DE)	-.704	-4.28	-5.32	-1.75	-1.40	-1.80	-2.17	-1.08	-1.25	-1.35
A(THE)	.0104	.00623	.0354	.726E-4	.00599	.00253	.00729	.00253	.00311	.00296
1/T(THE)1	.401	1.17	1.50	.535	.336	.398	.503	.180	.197	.215
1/T(THE)2	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
1/T(THE)3	.277	.220	.200	.269	.265	.252	.277	.264	.255	.252
Z(THE)1	25.3	31.8	35.0	26.0	26.4	27.7	30.8	26.5	27.4	27.8
W(THE)1										
N(HD/DE)	40.3	56.9	43.8	28.7	19.2	7.53	[illegible]	5.80	5.50	6.55
A(HD)	-.0186	.00473	.0343	-.00912	-.00630	.00182	.00727	.00122	.00280	.00304
1/T(HD)1	-1.57	8.62	12.2	-4.32	4.39	8.46	13.3	5.34	6.81	7.07
1/T(HD)2	2.37	-8.67	13.3	4.54	-4.70	13.3	14.5	-11.7	13.3	13.3
1/T(HD)3	13.3	13.3	-15.3	13.3	13.3	-16.3	-42.3	13.3	-15.9	-15.5
1/T(HD)4	.277	.218	.196	.267	.262	.240	.201	.257	.246	.244
Z(HD)1	25.3	32.7	35.6	26.2	26.7	28.7	32.3	27.0	28.0	28.4
W(HD)1										
N(AZP/DE)	35.7	359.	476.	142.	118.	168.	208.	60.3	115.	125.
A(AZP)	.00537	-.00189	-.00136	.548E-4	.000427	-.00114	-.000551	-.00162	-.000863	-.000542
1/T(AZP)1	-.0242	.00661	.0356	-.00923	-.00680	.00295	.00786	.00279	.00264	.00157
1/T(AZP)2	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
1/T(AZP)3	.115	.194	.229	.151	.121	.153	.149	.147	.137	.127
Z(AZP)1	2.08	3.59	4.23	2.02	1.87	2.58	3.35	1.95	2.27	2.46
W(AZP)1	.277	.220	.200	.270	.269	.253	.228	.265	.255	.262
Z(AZP)2	25.3	31.7	35.0	25.9	26.4	27.7	30.7	26.5	27.4	27.8
W(AZP)2										

TABLE XI-9

XB-70A THRUST TRANSFER FUNCTION FACTORS

SAS On — Bobweight Loop Open

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	40 K	50 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	13.3	13.3	13.3	13.3	1.48	13.3	13.3	1.54	1.58	1.68
1/T(DET)2	(.211)	(.575)	(.656)	(.390)	3.10	(.296)	(.317)	3.06	3.36	3.05
1/T(DET)3	(.101)	(.0533)	(.0722)	(.0726)	13.3	(.0496)	(.0542)	13.3	13.3	13.3
Z(DET)1	.667	.811	.735	.925	.404	.818	.794	.342	.356	.341
W(DET)1	1.41	3.09	3.78	2.10	.0501	2.79	3.23	.0394	.0407	.0636
Z(DET)2	.275	.222	.201	.272	.267	.253	.228	.265	.256	.257
W(DET)2	25.5	3[illegible]	34.5	25.5	25.9	27.3	30.3	26.1	27.0	27.3
NUMERATORS										
N(L /DTH)										
A(U)	.000105	.822E-4	.825E-4	.810E-4	.808E-4	.824E-4	.828E-4	.822E-4	.826E-4	.827E-4
1/T(U)1	-.0222	-.00785	-.00523	-.0142	-.00956	-.00424	-.00265	-.00470	-.00342	.00281
1/T(U)2	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Z(U)1	.664	.705	.629	.756	.752	.536	.528	.443	.474	.522
W(U)1	1.38	3.07	3.77	1.92	1.94	2.71	3.26	1.96	2.17	2.22
Z(U)2	.275	.222	.201	.273	.269	.255	.220	.267	.258	.248
W(U)2	25.5	31.2	34.5	25.4	25.9	27.3	30.3	26.1	27.0	27.3
N(W /DTH)										
A(W)	.160E-4	.261E-4	.254E-4	.197E-4	.219E-4	.191E-4	.207E-4	.135E-4	.145E-4	.158E-4
1/T(W)1	.0153	-.00445	-.00283	-.00850	-.00569	-.00211	-.00113	-.00231	-.00144	-.00104
1/T(W)2	.0254	.0539	.0871	.0824	.0819	.0928	.0975	.0937	.0922	.0921
1/T(W)3	9.52	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
1/T(W)4	13.3	45.0	66.2	33.8	49.9	112.	174.	163.	217.	268.
Z(W)1	.278	.221	.200	.272	.266	.252	.227	.264	.258	.281
W(W)1	25.1	31.9	35.2	26.1	26.5	27.9	31.0	26.6	27.5	27.9

TABLE XI-9 (Concluded)

N(THE/DTH)	.443E-6	.129E-5	.158E-5	.107E-5	.125E-5	.139E-5	.170E-5	.113E-5	.131E-5	.142E-5
A(THE)	13.3	.0463	.0846	.108	.0761	.0956	.0977	.101	.0910	.0084
1/T(THE)1	(.967)	1.14	1.44	.509	.305	.360	.465	.162	.187	.220
1/T(THE)2	(.403)	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
1/T(THE)3	.278	.220	.199	.269	.264	.251	.226	.263	.254	.251
Z(THE)1	25.2	31.9	35.2	26.0	26.5	27.9	31.0	26.6	27.5	27.9
W(THE)1										

N(HO /DTH)	-.212E-5	-.215E-4	-.216E-4	-.863E-5	-.112E-4	-.138E-4	-.174E-4	-.456E-5	-.809E-5	-.100E-4
A(HO)	.181	.0465	.0829	.0922	.0631	.0905	.0957	.0887	.0876	.0877
1/T(HO)1	3.82	-7.65	10.3	5.01	4.52	7.02	9.49	5.45	6.52	7.50
1/T(HO)2	13.3	8.07	-10.9	-8.60	-7.53	-8.30	-10.3	13.3	-11.4	-10.8
1/T(HO)3	-19.3	13.3	13.3	13.3	13.3	13.3	13.3	-15.4	13.3	13.3
1/T(HO)4	.343	.218	.198	.257	.255	.248	.228	.247	.248	[illegible]
Z(HO)1	23.4	32.1	35.4	26.9	27.4	28.7	31.2	27.4	28.0	[illegible]
W(HO)1										

N(AZP/DTH)	-.278E-4	-.595E-4	-.000129	-.848E-4	-.000101	-.000116	-.000148	-.970E-4	-.000113	-.000128
A(AZP)	-.0123	-.00201	-.00138	-.00457	-.00485	-.00134	-.000537	-.00180	-.00162	-.000657
1/T(AZP)1	.221	.0471	.0847	.103	.0704	.0948	.0975	.0966	.0916	.0902
1/T(AZP)2	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
1/T(AZP)3	.281	.155	.192	.132	.0695	.0724	.0751	.0703	.0652	.0614
Z(AZP)1	2.00	3.63	4.33	2.05	1.89	2.59	3.41	1.95	2.28	2.62
W(AZP)1	.277	.220	.199	.269	.265	.251	.226	.264	.254	.251
Z(AZP)2	25.3	31.8	35.2	26.0	26.5	27.9	30.9	26.6	27.5	27.9
W(AZP)2										

TABLE XI-10

XB-70A ELEVATOR TRANSFER FUNCTION FACTORS

SAS On — Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	60 K	60 K	60 K	60 K	60 K
M	.310	.800	.950	.650	.900	1.60	2.20	2.00	2.5[illegible]	3.0[illegible]
DENOMINATOR										
1/T(DET)1	14.4	10.9	11.6	11.5	1.84	12.2	12.4	1.88	2.05	1.96
1/T(DET)2	(.187)	(.494)	(.637)	(.348)	3.22	(.277)	(.302)	3.06	3.27	3.84
1/T(DET)3	(.0930)	(.0435)	(.0547)	(.0660)	11.8	(.0454)	(.0486)	12.4	12.6	13.3
Z(DET)1	.616	.622	.540	.863	.374	.760	.709	.366	.360	.378
W(DET)1	1.47	4.18	4.99	2.50	.0470	3.20	3.75	.0372	.0378	.0397
Z(DET)2	.256	.758	.229	.201	.287	.270	.241	.277	.260	.265
W(DET)2	25.6	31.2	34.4	25.4	25.8	27.2	30.2	26.1	27.0	27.3
NUMERATORS										
N(U /DE)										
A(U)	-4.26	-3.97	-3.13	-6.66	-6.72	-2.87	-1.96	-3.41	-2.60	-2.10
1/T(U)1	6.60	(.402)	(.314)	.297	.275	(.449)	32.6	61.1	38.0	35.3
1/T(U)2	66.8	(.866)	(1.01)	.501	.329	(.353)	115.	110.	163.	215.
Z(U)1	.928	.819	.756	.509	.899	.926	.0272	.898	.691	.606
W(U)1	.652	52.9	64.7	36.1	39.7	62.6	.431	.163	.182	.198
N(W /DE)										
A(W)	32.3	71.1	69.1	49.3	51.1	44.5	48.3	31.6	33.7	36.8
1/T(W)1	7.30	.0234	-.0130	(-.0505)	(-.0733)	.0108	-.0121	.00267	-.00860	-.00570
1/T(W)2	66.8	-.0240	.0423	(.0362)	(.0282)	-.0123	.0159	-.00246	.00232	.0110
1/T(W)3	(.0531)	(.819)	(.753)	(.508)	(.900)	(.926)	52.2	61.1	38.0	35.3
1/T(W)4	(.0941)	(53.2)	(64.9)	(36.3)	(39.7)	(62.6)	116.	110.	164.	215.
N(THE/DE)										
A(THE)	.620	2.90	3.70	2.13	2.41	2.72	3.44	2.12	2.58	2.01
1/T(THE)1	.0106	.00623	.0354	-.000258	.000242	.00254	.00753	.00221	.00206	.00280
1/T(THE)2	.601	1.16	1.48	.525	.327	.380	.484	.173	.195	.258
1/T(THE)3	66.7	77.1	75.4	46.8	38.4	42.0	40.5	35.9	34.7	33.4

TABLE XI-10 (Concluded)

N(HD /DE)										
A(HD)	-32.6	-71.2	-69.1	-49.8	-51.5	-44.6	-48.3	-31.7	-33.8	-36.0
1/T(HD)1	-.0186	:00469	.0343	-.00975	-.00704	.00153	.00725	.000478	.00235	.00273
1/T(HD)2	-1.59	-7.64	12.3	-3.85	-3.82	7.98	-12.8	8.17	6.54	7.71
1/T(HD)3	2.37	8.55	-12.4	4.48	4.35	-8.59	(.979)	-6.62	-8.23	-9.18
1/T(HD)4	66.8	49.8	41.7	38.7	30.2	22.1	(15.3)	23.1	22.3	27.6
N(AZP/DE)										
A(AZP)	-29.0	-212.	-293.	-159.	-184.	-221.	-287.	-176.	-214.	-247.
1/T(AZP)1	.00537	-.00190	-.00137	-.000188	.000163	-.00123	-.000578	-.00179	-.000927	-.000576
1/T(AZP)2	-.0242	.00659	.0356	-.00959	-.00725	00276	.00785	.00227	.00325	.00330
1/T(AZP)3	64.7	86.1	83.4	51.8	40.7	45.9	44.3	37.5	36.6	35.0
Z(AZP)1	.115	.185	.222	.134	.0866	.123	.123	.107	.102	.0614
W(AZP)1	2.08	3.56	4.24	2.02	1.87	2.58	3.37	1.95	2.78	2.61

TABLE XI-11

XB-70A THRUST TRANSFER FUNCTION FACTORS

SAS On -- Bobweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	14.4	10.9	11.6	11.5	1.94	12.2	12.4	1.85	2.05	1.96
1/T(DET)2	(.187)	(.494)	(.637)	(.348)	3.22	(.277)	(.302)	3.06	3.27	3.54
1/T(DET)3	(.0930)	(.0435)	(.0587)	(.0660)	11.8	(.0454)	(.0486)	12.4	12.4	12.3
Z(DET)1	.616	.622	.540	.863	.374	.760	.709	.264	.260	.329
W(DET)1	1.47	4.18	4.99	2.50	.0470	3.20	3.75	.0372	.0378	.0397
Z(DET)2	.256	.258	.229	.301	.287	.270	.241	.277	.268	.265
W(DET)2	25.6	31.2	34.4	25.4	25.8	27.2	30.2	26.1	27.0	27.3
NUMERATORS										
N(U /DTH)										
A(U)	.000105	.822E-4	.825E-4	.810E-4	.808E-4	.824E-4	.828E-4	.822E-4	.826E-4	.827E-4
1/T(U)1	-.0206	-.00593	-.00394	-.0128	-.00889	-.00375	-.00225	-.00433	-.00306	-.00241
1/T(U)2	14.4	11.1	11.8	11.6	12.1	12.4	12.6	12.7	12.7	12.6
Z(U)1	.592	.516	.439	.674	.701	.476	.448	.412	.431	.471
W(U)1	1.44	4.11	4.93	2.30	2.20	3.09	3.72	2.15	2.37	2.53
Z(U)2	.255	.259	.230	.303	.290	.271	.243	.279	.270	.267
W(U)2	25.6	31.2	34.5	25.4	25.8	27.3	30.3	26.1	27.0	27.3
N(W /DTH)										
A(W)	.140E-4	.241E-4	.254E-4	.197E-4	.219E-4	.191E-4	.207E-4	.135E-4	.145E-4	.158E-4
1/T(W)1	(-.0667)	-.00427	-.00277	-.00358	-.00573	-.00210	-.00112	-.00231	-.00146	-.00104
1/T(W)2	(.0312)	.0567	.0881	.0773	.0490	.0924	.0975	.0033	.0023	.0025
1/T(W)3	(.987)	14.0	14.1	13.5	13.5	13.7	13.7	13.8	13.5	13.5
1/T(W)4	(11.1)	44.5	65.8	33.7	49.8	112.	174.	160.	217.	268.
Z(W)1	.297	.219	.196	.271	.265	.247	.221	.261	.252	.249
W(W)1	25.0	31.7	34.9	26.0	26.5	27.8	30.9	26.9	27.9	27.9

TABLE XI-11 (Concluded)

N(THE/DTH)	.443E-6	.129E-5	.158E-5	.107E-5	.125E-5	.139E-5	.170E-5	.113E-5	.131E-5	.147E-5
A(THE)	13.0	.0447	.0845	.110	.0772	.0958	.0977	.102	.0900	.0880
1/T(THE)1	(.023)	1.11	1.39	.499	.298	.352	.453	.159	.186	.208
1/T(THE)2	(.408)	13.7	13.8	13.4	13.4	13.6	13.7	13.5	13.5	13.5
1/T(THE)3	.285	.214	.192	.268	.262	.246	.221	.261	.252	.248
Z(THE)1	25.2	31.9	35.2	26.0	26.5	27.9	31.0	26.6	27.5	27.9
W(THE)1										

N(HD/DTH)	-.212E-5	-.215E-4	-.216E-4	-.863E-5	-.112E-4	-.138E-4	-.174E-4	-.456E-5	-.809E-5	-.109E-4
A(HD)	.173	.0449	.0820	.0898	.0620	.0896	.0953	.0876	.0868	.0872
1/T(HD)1	-22.0	-7.69	-11.0	4.86	4.47	7.27	-10.4	5.42	6.58	7.60
1/T(HD)2	(.927)	8.30	(.996)	-8.35	-7.44	-8.38	10.4	13.6	-11.4	-10.0
1/T(HD)3	(5.66)	13.1	(11.8)	14.6	13.9	12.9	11.7	-15.4	13.3	13.2
1/T(HD)4	.475	.218	.203	.233	.244	.253	.233	.241	.249	.249
Z(HD)1	27.6	32.1	35.4	26.8	27.1	28.2	31.2	27.4	28.0	28.2
W(HD)1										

N(AZP/DTH)	-.278E-4	-.595E-4	-.000129	-.848E-4	-.000101	-.000116	-.000168	-.970E-4	-.000113	-.000128
A(AZP)	-.0123	-.0201	-.00138	-.00697	-.00485	-.00134	-.000527	-.00182	-.00102	-.000657
1/T(AZP)1	.221	.0471	.0847	.103	.0704	.0948	.0976	.0966	.0916	.0900
1/T(AZP)2	13.3	13.9	14.0	13.5	13.5	13.8	13.8	13.5	13.5	13.5
1/T(AZP)3	.260	.159	.197	.130	.0689	.0748	.0787	.0710	.0664	.0627
Z(AZP)1	2.00	3.55	4.22	2.04	1.88	2.55	3.35	1.94	2.26	2.61
W(AZP)1	.277	.211	.189	.267	.262	.243	.219	.260	.251	.248
Z(AZP)2	25.3	31.9	35.2	26.0	26.5	27.9	30.0	26.6	27.5	27.9
W(AZP)2										

TABLE XI-12

XB-70A LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.50	2.20	2.00	2.50	3.00
Bobweight Loop Open										
D(G)/D(U) (DEG/KT)	.0554	-.0128	-.103	.0333	.0270	-.00273	-.0218	.00190	-.00481	-.00172
NZA (G/RAD)	5.78	30.4	46.9	9.70	8.59	18.3	31.8	10.5	14.3	18.8
DE/G (DEG/G)	16.6	1.13	.570	5.52	9.34	7.02	3.48	12.9	7.68	4.19
CAP (RAD/SEC/SEC/G)	.243	.147	.119	.252	.366	.381	.281	.353	.277	.178
PHUGOID(2) (SEC) (TUCK(2))	--	(7.36)	(14.71)	--	(16.11)	--	--	--	--	(77.01)
1/C(1/10)	2.00	2.36	1.52	1.69	1.42	.696	.569	.400	.287	.260
Bobweight Loop Closed										
FST/KT (LB/KT)	-.338	.0807	.0256	-.0513	.0589	-.0191	-.0173	-.0494	-.0113	.00797
FST/G (LB/G)	71.2	16.2	13.8	30.2	45.3	39.4	28.[illegible]	57.7	41.4	27.4

TABLE XI-13

XB-70A LATERAL DIRECTIONAL DIMENSIONAL DERIVATIVES

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
YV	-.0508	-.213	-.266	-.0499	-.0352	-.113	-.129	-.0473	-.0548	-.0623
YB	-17.6	-190.	-282.	-31.0	-30.6	-175.	-275.	-91.6	-133.	-181.
LB'	-5.04	9.67	-9.19	-6.11	-6.18	2.90	4.81	1.94	1.99	-.569
NB'	.898	1.60	3.73	.889	.881	2.04	2.21	.811	.912	1.16
LP'	-1.71	-4.02	-7.36	-1.05	-1.26	-1.16	-1.03	-.393	-.413	-.438
NP'	-.156	.0533	.145	.0417	.0572	-.0219	-.0507	-.0170	-.0193	-.0115
LR'	-.213	-.636	-1.01	.259	.0927	-.202	-.0625	-.0399	.0212	.0849
NR'	-.200	-.375	-.415	-.140	-.0883	-.307	-.367	-.134	-.151	-.174
Y*DA	-.0175	-.0129	-.0133	-.00914	-.00176	.000481	0.	.231E-4	0.	0.
L'DA	2.78	5.24	3.54	4.01	3.54	1.51	1.67	.966	.993	1.07
N'DA	-.125	-.0386	-.201	-.0936	-.188	-.166	-.107	-.0638	-.0395	-.0427
Y*DR	.0333	.0515	.0531	.0249	.0149	.0183	.0182	.00750	.00721	.00693
L'DR	.118	-.0881	-4.71	.260	-.455	2.10	1.75	.800	.481	.285
N'DR	-.568	-1.24	-1.41	-.421	-.330	-.845	-1.07	-.425	-.485	-.582

TABLE XI-14

XB-70A AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.900	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	.0287	-.0158	.00706	.0270	.0133	-.00576	-.0131	-.0178	-.0152	-.000645
1/T(DET)2	1.77	4.15	7.27	.678	.745	1.19	.966	.396	.395	.436
Z(DET)1	.0615	.184	.197	.217	.266	.145	.200	.126	.137	.108
W(DET)1	1.27	1.28	1.94	1.23	1.16	1.38	1.43	.779	.875	1.10
NUMERATORS										
N(B /DA)										
A(B)	-.0175	-.0129	-.0133	-.00914	-.00176	.000481	.174	.231E-4	.116	.106
1/T(B)1	.0485	-21.9	.0451	-66.1	.0685	.0359	.0390	.0320	.0348	.0406
1/T(B)2	1.94	(.559)	3.58	(.786)	.241	1.06	1.37	.394	.484	.464
1/T(B)3	-27.9	(.505)	-23.0	(.213)	-368.	547.		7269.		
N(P /DA)										
A(P)	2.78	5.24	3.54	4.01	3.54	1.51	1.67	.966	.993	1.07
1/T(P)1	-.0119	-.00193	-.00131	-.00691	-.00483	-.00132	-.000596	-.00179	-.00102	-.000653
Z(P)1	.184	.216	.211	.118	.0851	.144	.156	.0960	.103	.109
W(P)1	.829	1.32	1.83	.866	.743	1.55	1.60	.970	.998	1.07
N(R /DA)										
A(R)	-.125	-.0386	-.201	-.0936	-.188	-.166	-.107	-.0638	-.0395	-.0427
1/T(R)1	.407	-5.01	-.505	.430	.288	.283	.319	.148	.166	.180
1/T(R)2	-.607	(.991)	.655	1.50	1.12	-.795	-.776	-1.01	-1.07	-1.06
1/T(R)3	5.55	(1.28)	5.18	-2.54	-1.19	1.98	2.41	1.56	1.86	1.67
N(PHI/DA)										
A(PHI)	2.76	5.24	3.53	4.00	3.52	1.50	1.67	.959	.990	1.07
Z(PHI)1	.157	.215	.208	.115	.0 04	.140	.155	.0923	.101	.108
W(PHI)1	.834	1.32	1.83	.874	.752	1.55	1.60	.979	1.00	1.08
N(AYP/DA)										
A(AYP)	.146	19.9	-10.0	12.0	3.84	-5.34	.791	.279	2.79	3.01
1/T(AYP)1	.0691	.157	.0251	-.150	.127	.0423	.0419	.0381	.0390	.0441
1/T(AYP)2	-497.	-1.93	19.0	.234	-.181	3.90	-19.1	-11.3	-1.84	-1.96
Z(AYP)1	-.198	.245	.133	.0817	-.196	-.192	.124	.0259	.430	.586
W(AYP)1	.811	1.44	1.87	1.86	1.99	1.41	2.00	1.27	1.14	1.18

TABLE XI-15

XB-70A RUDDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	.0287	-.0158	.00706	.0270	.0133	-.00576	-.0131	-.0178	-.0152	-.000645
1/T(DET)2	1.77	4.15	7.27	.678	.745	1.19	.966	.396	.395	.436
Z(DET)1	.0615	.184	.197	.217	.266	.145	.200	.126	.137	.108
W(DET)1	1.27	1.28	1.94	1.23	1.16	1.38	1.43	.779	.875	1.10
NUMERATORS										
N(B /DR)										
A(B)	.0333	.0515	.0531	.0249	.0149	.0183	.0182	.00750	.00721	.00693
1/T(B)1	.00130	.00337	-.00292	-.0153	-.0114	.0140	.00807	.00860	.00281	-.000649
1/T(B)2	1.73	4.07	10.5	.955	1.56	1.13	1.08	.395	.419	.436
1/T(B)3	17.5	24.4	19.8	18.4	17.8	53.9	42.9	68.0	72.3	86.6
N(P /DR)										
A(P)	.118	-.0881	-4.71	.260	-.455	2.10	1.75	.800	.481	.285
1/T(P)1	-.0121	-.00197	-.00135	-.00694	-.00485	-.00132	-.000599	-.00180	-.00102	.0465
1/T(P)2	4.77	6.67	(.0939)	2.62	(.0860)	(.146)	(.128)	(.0821)	(.0631)	(-.0555)
1/T(P)3	-4.91	-20.7	(2.57)	-3.43	(2.31)	(1.80)	(2.28)	(1.36)	(1.71)	(.773E-4)
N(R /DR)										
A(R)	-.968	-1.24	-1.41	-.421	-.330	-.845	-1.07	-.425	-.485	-.582
1/T(R)1	1.55	-.274	7.71	.570	.473	.243	.266	.142	.152	.105E-6
Z(R)1	.178	(.303)	.444	.317	[illegible]	(-.455)	(-.367)	(-.497)	(-.367)	(.0485)
W(R)1	.538	(4.14)	.292	.708	.757	(1.49)	(1.30)	(.813)	(.688)	(.444)
N(PHI/DR)										
A(PHI)	.0433	-.156	-4.78	.203	-.498	2.05	1.71	.754	.443	.750
1/T(PHI)1	6.53	6.28	(.114)	2.83	(.107)	(.138)	(.123)	(.0735)	(.0540)	.0465
1/T(PHI)2	-9.93	-12.3	(2.56)	-4.16	(2.23)	(1.83)	(2.31)	(1.41)	(1.78)	-.0414
N(AYP/DR)										
A(AYP)	-43.9	-76.2	-113.	-23.9	-22.3	-40.2	-54.0	-21.7	-26.7	-34.9
1/T(AYP)1	-.0747	.0133	-.0119	-.0606	-.0352	.0259	.0148	.0170	.00732	-.000651
1/T(AYP)2	1.07	4.23	5.78	.383	.332	1.68	1.54	.755	.583	.439
Z(AYP)1	.715	-.125	.0668	.337	.406	-.194	-.103	-.169	-.0610	.00299
W(AYP)1	.516	1.38	1.59	1.07	1.10	1.26	1.74	.891	1.19	1.55

TABLE XI-16

XB-70A AILERON TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	.0153	-.0115	.00513	.00647	.00415	-.00392	-.00683	-.00774	-.00663	-.000649
1/T(DET)2	.466	.397	.388	.351	.350	.345	.345	.382	.371	.343
1/T(DET)3	3.00	6.73	8.86	2.75	2.65	2.00	1.90	.953	.943	.955
Z(DET)1	.377	.781	.633	.304	.335	.215	.278	.147	.193	.217
W(DET)1	1.05	1.12	1.88	.957	.865	1.38	1.42	.777	.855	1.06
NUMERATORS										
N(B /DA)										
A(B)	-.0175	-.0129	-.0133	-.00914	-.00176	.000481	.173	.231E-4	.115	.106
1/T(B)1	.0317	.0723	.0288	.147	.0511	.0337	.0354	.0290	.0310	.0351
1/T(B)2	.442	-21.7	.498	-68.0	.266	.333	.340	.257	.271	.268
1/T(B)3	2.25	(.933)	4.05	(.961)	.405	1.13	1.48	.563	.669	.667
1/T(B)4	-27.5	(1.09)	-21.3	(.320)	-367.	545.		7261.		
N(P /DA)										
A(P)	2.78	5.24	3.54	4.01	3.54	1.51	1.67	.966	.993	1.07
1/T(P)1	-.0118	-.00193	-.00131	-.00691	-.00483	-.00132	-.000596	-.00179	-.00102	-.000653
1/T(P)2	.504	.444	.357	.348	.354	.341	.344	.349	.352	.353
Z(P)1	.537	.773	.711	.176	.150	.206	.251	.166	.190	.209
W(P)1	.674	1.14	1.77	.846	.721	1.53	1.57	.947	.971	1.04
N(R /DA)										
A(R)	-.125	-.0386	-.201	-.0936	-.188	-.166	-.107	-.0638	-.0395	-.0427
1/T(R)1	.333	.333	.333	.333	.288	.283	.319	.148	.166	.180
1/T(R)2	.407	-5.01	-.505	.430	.333	.333	.333	.333	.333	.333
1/T(R)3	-.607	(.991)	.655	1.50	1.12	-.795	-.776	-1.01	-1.07	-1.06
1/T(R)4	5.55	(1.28)	5.18	-2.54	-1.19	1.98	2.41	1.56	1.86	1.67

TABLE XI-16 Continued

N(PHI/UA)										
A(PHI)	2.76	5.24	3.53	4.00	3.52	1.50	1.67	.959	.990	1.07
1/T(PHI)1	.501	.445	.358	.348	.354	.341	.344	.349	.352	.353
Z(PHI)1	.507	.772	.708	.172	.145	.202	.249	.162	.188	.208
W(PHI)1	.680	1.14	1.77	.654	.730	1.54	1.58	.956	.975	1.04
N(AYP/DA)										
A(AYP)	.146	19.9	-10.0	12.0	3.84	-5.34	.791	.279	2.79	3.01
1/T(AYP)1	.0504	.0734	.0206	-.160	.113	.0411	.0393	.0358	.0357	.0392
1/T(AYP)2	.454	.724	.426	.211	-.206	.338	.341	.313	.309	.304
1/T(AYP)3	-457.	-2.08	16.6	.360	.344	3.[illegible]	-16.8	-9.47	-1.79	-1.89
Z(AYP)1	-.0762	.734	.445	.137	-.0790	-.174	.187	.108	.513	.660
W(AYP)1	.534	1.37	1.94	1.53	1.94	1.45	2.18	1.48	1.25	1.33

TABLE XI-17

XB-70A RUDDER TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DENOMINATOR										
1/T(DET)1	.0153	-.0115	.00513	.00647	.00415	-.00392	-.00683	-.00774	-.00663	-.000649
1/T(DET)2	.466	.397	.388	.351	.350	.345	.345	.382	.371	.353
1/T(DET)3	3.00	6.73	8.86	2.75	2.65	2.00	1.90	.953	.943	.955
Z(DET)1	.377	.781	.633	.304	.335	.215	.278	.147	.193	.217
W(DET)1	1.05	1.12	1.88	.957	.865	1.38	1.42	.777	.855	1.06
NUMERATORS										
N(B /DP)										
A(B)	.0333	.0515	.0531	.0249	.0149	.0183	.0182	.00750	.00721	.00693
1/T(B)1	-.00454	.00126	-.00251	-.00985	-.00747	.00944	.00464	.00368	.000840	-.000654
1/T(B)2	.333	.333	.333	.333	.333	.333	.333	.333	.333	.333
1/T(B)3	3.07	6.73	(.967)	2.72	4.10	1.60	1.79	.75[illegible]	.864	.947
1/T(B)4	17.6	24.3	(16.3)	18.7	17.0	54.1	63.1	68.1	72.4	86.6
N(P /DR)										
A(P)	.118	-.0881	-4.71	.260	-.455	2.10	1.75	.800	.481	.285
1/T(P)1	-.0121	-.00197	-.00135	-.00694	-.00485	-.00132	-.000599	-.00180	-.00102	.0485
1/T(P)2	.333	.333	.333	.333	.333	.333	.333	.333	.333	.333
Z(P)1	(4.77)	(6.67)	.0939	(2.62)	.0860	.146	.128	.0821	.0631	-.0555
W(P)1	(-4.91)	(-20.7)	2.57	(-3.43)	2.31	1.80	2.28	1.36	1.71	.773E-4
N(R /DR)										
A(R)	-.568	-1.24	-1.41	-.421	-.330	-.845	-1.07	-.425	-.485	-.582
1/T(R)1	.333	-.198	.333	.333	.333	.219	.227	.129	.131	.482E-7
1/T(R)2	2.95	.258	9.82	2.74	2.92	.333	-.280	.333	-.269	.0485
1/T(R)3	(.214)	.333	(.494)	(.389)	(.514)	-.379	.333	-.389	.333	.333
1/T(R)4	(.390)	6.73	(.258)	(.322)	(.305)	1.99	2.00	1.14	1.09	.969

TABLE XI-17 Continued

V(PHI/DF)										
A(PHI)	.0433	-.158	-4.78	.203	-.498	2.05	1.71	.754	.443	.250
1/T(PHI)1	.333	.333	.333	.333	.333	.333	.333	.333	.333	.0485
1/T(PHI)2	5.67	6.68	(.119)	2.61	(.144)	(.134)	(.119)	(.0643)	(.0428)	-.134
1/T(PHI)3	-11.5	-11.5	(2.56)	-4.50	(2.23)	(1.83)	(2.31)	(1.41)	(1.78)	.333
V(AYP/DR)										
A(AYP)	-43.9	-76.2	-113.	-23.9	-22.3	-40.2	-54.0	-21.7	-26.7	-34.9
1/T(AYP)1	-.0475	.00777	-.00867	-.0371	-.0213	.0200	.00934	.00885	.00314	-.000655
1/T(AYP)2	.333	.333	.333	.333	.333	.333	.333	.333	.333	.333
1/T(AYP)3	7.86	6.73	7.80	2.76	2.46	2.43	2.34	1.22	1.11	.967
Z(AYP)1	.362	-.0860	.0496	.367	.435	-.168	-.0869	-.144	-.0420	.00968
W(AYP)1	.423	.37	1.65	.534	.553	1.25	1.76	.933	1.72	1.54

TABLE XI-18

XB-70A LATERAL DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DR PERIOD (SEC)	4.94	4.98	3.30	5.25	5.60	4.60	4.50	8.13	7.25	5.75
1/C(1/2)	.559	1.70	1.82	2.02	2.21	1.32	1.85	1.15	1.25	.989
SPIRAL (2) (SEC)	--	43.9	--	--	--	180.	52.8	38.9	45.6	1075.
P(1)	1.11	1.45	.461	2.20	1.67	1.70	2.28	4.06	3.32	2.34
P(2)	-.0279	1.38	.398	1.59	.869	1.55	2.22	3.89	--	2.33
P(3)	1.04	1.50	.435	2.82	2.04	1.70	2.40	4.72	--	2.35
P(2)/P(1)	-.0251	.954	.863	.724	.521	.909	.973	.958	--	.995
P(OSC)/P(AV)	1.05	.0329	.0593	.160	.315	.0473	.0135	.0605	--	.00265
W(PHI)/W(D)	.655	1.03	.943	.713	.646	1.13	1.12	1.26	1.15	.974
DEL-B-MAX	.607	.0689	.0658	.452	.447	.219	.175	.510	.303	.165
PHI TO BETA, PHASE	48.7	244.	55.2	22.8	386.	211.	197.	194.	190.	22.3
PHI TO BETA	1.86	1.90	.652	3.42	3.56	1.31	2.17	3.15	2.57	.405
PHI TO VE	.308	.122	.0352	.433	.471	.0973	.117	.302	.198	.0259

XB-70A DATA SOURCES

Estimated Aerodynamic Derivatives, XB-70, North American Rept. No. NA-51-707, 29 June 1962

Aerodynamic Coefficients Obtained from Flight Test Data, XB-70, North American Rept. No. TFD-67-277, 14 Apr. 1967

Wolowicz, Chester H., et al, Preliminary Flight Evaluation of the Stability and Control Derivatives and Dynamic Characteristics of the Unaugmented XB-70-1 Airplane Including Comparisons with Predictions, NASA TND-4578, May 1968

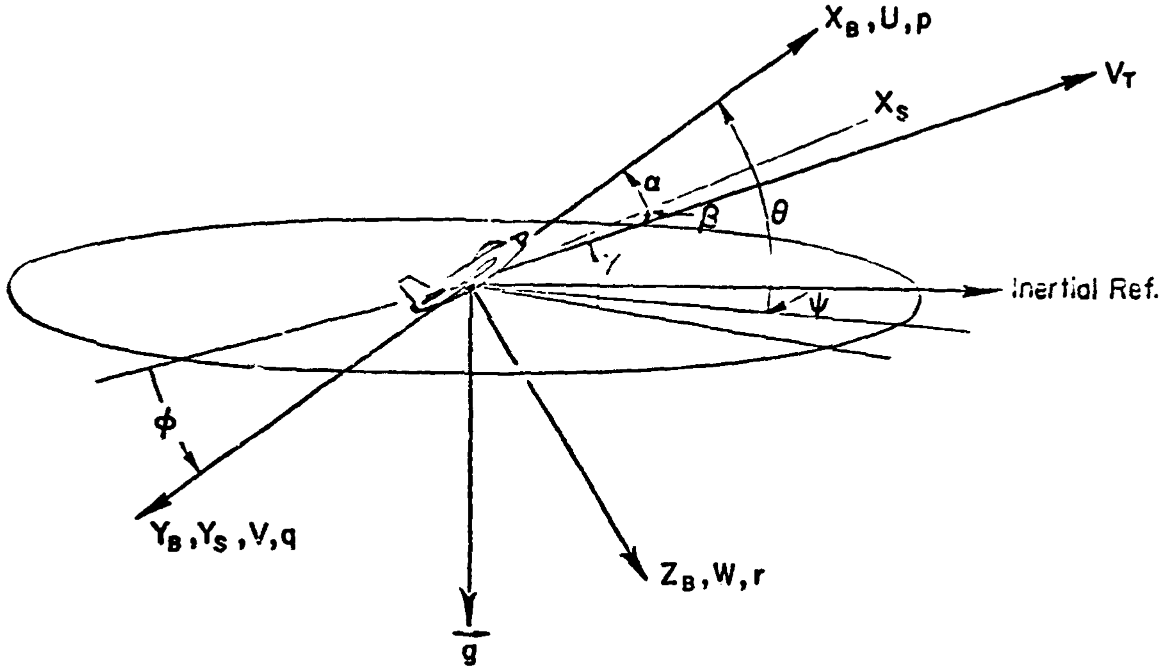
Estimated Performance Report for the XB-70A Air Vehicle No. 1, North American Rept. No. NA-64-660, 26 Oct. 1964

XB-70 Flight Control System Summary Test Report, North American Rept. No. NA-66-360, 30 Sept. 1966

APPENDIX A

AXIS SYSTEMS, SYMBOLS, COMPUTER
MNEMONICS, AND DERIVATIVE DEFINITIONS

1. AXIS SYSTEMS



X_B, Y_B, Z_B – The Body-Axis System consists of right-handed, orthogonal axes whose origin is fixed at the nominal aircraft center of gravity. It's orientation remains fixed with respect to the aircraft, the X_B and Z_B axes being in the plane of symmetry. The exact alignment of X_B axis is arbitrary, herein it is taken along the body centerline reference.

X_S, Y_S, Z_S – The Stability-Axis System is that particular body-axis system for which the X_S-axis is coincident with the projection of the total steady-state velocity vector (V_{T_o}) on the aircraft's plane of symmetry. It's orientation remains fixed with respect to the aircraft.

2. SYMBOLS

a	Speed of sound in air	ft/sec
a_y	Lateral acceleration along the y-body axis at the center of gravity (positive out right wing)	ft/sec^2
a'_y	Lateral acceleration parallel to the y-body axis at a distance ℓ_x and ℓ_z from the c.g., $a'_y = a_y + \ell_x\dot{r} - \ell_z\dot{p}$	ft/sec^2
a'_z	Normal acceleration parallel to the z-body axis at a distance ℓ_x from the c.g., $a'_z = a_z - \ell_x\dot{q}$	ft/sec^2
a_z^B	Normal acceleration parallel to the z-body axis at a distance ℓ_B from the c.g.	
b	Reference wing span	ft
[illegible]	Bobweight gain	lb/g
B.L.	Buttock line	
$\bar{c}$	Reference chord	ft
C	Longitudinal feel system damping	lb/in./sec
c.g.	Center of gravity	
D	Aerodynamic force (drag) along the total velocity vector (positive aft)	lb
FRL	Fuselage reference line (parallel to x-body axis)	
F.S.	Fuselage station	
	Longitudinal control column force (+ aft)	lb
F_{ST}	Longitudinal stick force (+ aft)	lb
F_{ST}^{LAT}	Lateral stick force (+ right)	lb
F_{ped}	Rudder pedal force (+ right)	lb
g	Acceleration due to gravity	ft/sec^2
G	Pilot control to surface gearing	deg/in. or deg/deg

h	Altitude	ft
I	Longitudinal feel system inertia	lb/in./sec^2
I_x, I_y, I_z	Moments of inertia referred to body axis (unless otherwise specified)	slug-ft^2
I_{xz}	Product of inertia referred to body axis (unless otherwise specified)	slug-ft^2
$j\omega$	The imaginary portion of the complex variable $s = \sigma \pm j\omega$	rad/sec
ℓ_B	Effective distance of bobweight from c.g. (positive forward)	ft
ℓ_x	Distance along the x-body axis from the c.g. (positive forward)	ft
ℓ_{th}	Perpendicular distance from c.g. to thrust line (positive for nose-up pitching moment	
ℓ_z	Distance along the z-body axis from the c.g. (positive down)	ft
K	Longitudinal feel system spring constant	lb/in.
KTAS	Knots true airspeed	
KCAS	Knots calibrated airspeed	
K'	Feel system spring constant per unit dynamic pressure	(lb/in.)/psf
L	Rolling moment about the x-axis due to aerodynamic torques (positive right wing down)	ft-lb
L	Aerodynamic force (lift) perpendicular to the total velocity vector in the aircraft's plane of symmetry (positive up)	lb
m	Mass	slugs
M	Mach number	
M	Pitching moment about the y-axis due to aerodynamic torques (positive nose up)	ft-lb
MAC	Mean aerodynamic chord	ft
MGC	Mean geometric chord	ft

N	Aerodynamic normal force along the z-body axis, <u>but</u> positive up	lb
N	Yawing moment about z-axis due to aerodynamic torques (positive nose right)	ft-lb
p	Roll rate, angular velocity about x-axis (positive right wing down)	rad/sec
q	Pitch rate, angular velocity about y-axis (positive nose up)	rad/sec
$\bar{q}$	Dynamic pressure, $1/2\ \rho\ V_{T_o}^2$	lb/ft^2
r	Yaw rate, angular velocity about z-axis (positive nose right)	rad/sec
r_{RG}	Yaw rate gyro signal	rad/sec
s	Laplace operator, $\sigma + j\omega$	rad/sec
S	Reference wing area	ft^2
TED	Trailing edge down	
TEU	Trailing edge up	
TL	Thrust line	
u	Linear perturbed velocity along the x-axis (positive forward)	ft/sec
U_o	Linear steady-state velocity along the x-axis (positive forward)	ft/sec
v	Linear perturbed velocity along the y-axis (positive out right wing)	ft/sec
V_s	Stall speed	
V_{T_o}	Total linear steady-state velocity (positive forward)	kt
w	Linear perturbed velocity along the x-axis (positive down)	
W.L.	Water line	in.
W	Weight	lb
W_o	Linear steady-state velocity along the z-axis (positive down)	ft/sec

X	Aerodynamic force along the x-axis (positive forward)	
Y	Aerodynamic force along y-axis (positive out right wing)	lb
Z	Aerodynamic force along z-axis (positive down)	lb
α	Perturbed angle of attack	rad
α_o	Steady-state (trim) angle of attack relative to the FRL	deg
β	Sideslip angle	rad
γ_o	Steady-state flight path angle	deg
δ_a	Aileron control surface deflection (includes spoiler effects, etc.) (positive for positive rolling moment)	rad
δ_e	Elevator surface deflection from trim (positive for nose-down pitching moment for aft surface)	rad
δ_{e_o}	Trim elevator deflection	deg
δ_{cc}	Longitudinal control column deflection from trim (positive aft)	deg
δ_{ST}	Longitudinal stick deflection from trim (positive aft)	in.
δ_{ST}^{LAT}	Lateral stick deflection from trim (positive right)	in.
δ_{ped}	Rudder pedal deflection from trim (positive right pedal forward)	in.
δ_w	Lateral wheel deflection from trim (positive about x-axis)	deg
δ_s	Stabilizer surface deflection from trim (positive for TED)	rad
δ_{sp}	Spoiler surface deflection (positive up)	rad
δ_v	Vertical tail deflection from trim (positive for nose-left yawing moment)	rad
δ_r	Rudder deflection [positive for nose-left yawing moment (negative N)]	rad

Δ	Denominator of airframe transfer function	
ϵ	Angle between principle inertia axis and FRL (positive about y-axis)	deg
ζ_i	Damping ratio of linear second-order mode particularized by the subscript	
θ	Pitch angle, $\int q\,dt$ for straight and level flight, positive nose up	rad
i_{TH}	Inclination of thrust line with FRL [positive gives negative (−) z force]	deg
ρ	Mass density of air	slugs/ft^3
σ	The real portion of the complex variable $s = \sigma \pm j\omega$	rad/sec
φ	Roll angle, $(\cos\theta_o \int p\,dt - \sin\theta_o \int r\,dt)$ in straight and level flight (positive right wing down)	rad
ω_i	Undamped natural frequency of a second-order mode, particularized by subscript	rad/sec

Special Subscript

a	Aileron
cc	Control column
d	Dutch roll
e	Elevator
G	Gyro
INS	Inertial navigation system
p	Phugoid
r	Rudder
R	Roll subsidence
s	Spiral
SAS	Stability augmentation system
sp	Short period
ST	Stick

Special Superscript

DIR	Directional control system (e.g., rudder pedal)	
LAT	Lateral control system	

Symbols Unique to Specific Aircraft

ARI	Aileron-rudder interconnect (F-4)	
BLC	Boundary layer control (F-104, F-4)	
K_{FLEX}^{DIR}	Rudder flexure coefficient (F-4)	
P_{BF}	Bellows force parameter (F-4)	ft^2
q_B	Bellows pressure (F-4)	lb/ft^2
δ_d	Yaw damper surface deflection (F-104) (positive for nose-left yawing moment)	rad
δ_{t_a}	Aileron tab deflection (CV-880M)	rad
$\delta_{t_{ac}}$	Commanded aileron tab deflection (CV-880M)	rad
δ_{t_e}	Elevator tab deflection (CV-880M)	rad
$(\delta_{t_e} - \delta_e)_c$	Commanded elevator-elevator servo tab combination (input linkage) (CV-880M)	rad
δ_{t_r}	Rudder tab deflection (CV-880M)	rad
$(\delta_{t_r} - \delta_r)_c$	Commanded rudder-rudder servo tab combination (input linkage)(CV-880M)	rad

3. COMPUTER PRINTOUT MNEMONICS

a. DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

COMPUTER PRINT OUT	STANDARD NOTATION, DEFINITION
S	S, wing reference area
B	b, wing span
C	$\bar{c}$, mean geometric chord
F/C#	Flight Condition number
H(FT)	h, altitude, feet
SL	Sea Level
M(-)	M, Mach number
VTO(FPS)	V_{T_O}, true airspeed, knots
VTO(KTAS)	V_{T_O}, true airspeed knots
VTO(KTCS)	V_{T_O}, calibrated airspeed, knots
W(LBS)	W, weight, pounds
C.G.(MGC)	c.g., center of gravity relative to mean geometric chord
IX	I_x } Body axis (FRL) moments of inertia, slugs-ft^2
IY	I_y
IZ	I_z
IXZ	I_{xz}
EPSILON(DEG)	ϵ, inclination of principle axis with respect to FRL, degrees
Q(PSF)	q, dynamic pressure, psf
QC(PSF)	q_c, impact pressure, psf
ALPHA(DEG)	α_o, FRL angle of attack, degrees
GAMMA(DEG)	γ_o, flight path angle, degrees
LXP(FT)	ℓ_x, x distance to pilot, ft
LZP(FT)	ℓ_z, z distance to pilot, ft
ITH(DEG)	i_{th}, thrust incidence with respect to FRL, degrees
XI(DEG)	ξ_o, $i_{th} + \alpha_o$, degrees
LTH(FT)	ℓ_{th}, perpendicular distance to thrust line from c.g., ft

b. LONGITUDINAL PARAMETERS

COMPUTER PRINT OUT	STANDARD NOTATION, DEFINITION	
XU*	X_u^*	1/sec
ZU*	Z_u^*	1/sec
MU*	M_u^*	1/sec-ft
XW	X_w	1/sec
ZW	Z_w	1/sec
MW	M_w	1/sec-ft
ZWD	$Z_{\dot{w}}$	$1/sec^2$
ZQ	Z_q	1/sec
MWD	$M_{\dot{w}}$	1/sec-ft
MQ	M_q	1/sec
†XDDD	X_δ	ft/sec^2-rad
ZDDD	Z_δ	ft/sec^2-rad
MDDD	M_δ	$1/sec^2$
DTH	δ_{th}	Thrust
FST	Fst	Stick force
U	u	fps
W	w	fps
THE	θ	rad
HD	$\dot{h}$	fps
AZP	a_z'	ft/sec^2 at $X = \ell_x$

†DDD signifies a control surface, e.g., for elevator DDD = DE; for aileron DDD = DA

c. LATERAL-DIRECTIONAL PARAMETERS

COMPUTER PRINT OUT	STANDARD NOTATION, DEFINITION	
YV	Y_v	1/sec
YB	Y_β	ft/sec^2
LB'	L'_β	1/sec^2
NB'	N'_β	1/sec^2
LP'	L'_p	1/sec
NP'	N'_p	1/sec
LR'	L'_r	1/sec
NR'	N'_r	1/sec
†Y*DDD	Y^*_δ	1/sec
L'DDD	L'_δ	1/sec^2
N'DDD	N'_δ	1/sec^2
B	β	rad
P	p	rad/sec
R	r	rad/sec
PHI	φ	rad
AYP	a'_y	ft/sec^2 at ℓ_x, ℓ_z

†DDD signifies a control surface, e.g., for elevator DDD = DE; for aileron DDD = DA.

d. TRANSFER FUNCTION PARAMETERS

The following shorthand notation is used to print the factored polynomials for all transfer functions*:

$$(s + 1/T_x)_i = 1/T_{x_i} \quad , \quad i = 1 \text{ to } k$$

$$(s^2 + 2\zeta\omega_n s + \omega_n^2)_j = \zeta_j;\omega_{n_j} \quad , \quad j = 1 \text{ to } \ell$$

where $k + 2\ell = n$, the order of the polynomial

COMPUTER PRINT OUT	STANDARD NOTATION, DEFINITION
DET	Roots of the denominator
N(X/Y)	Numerator N_y^x
A(X)	Gain of the transfer function x/y
†1/T(X)I	$1/T_{x_i}$, rad/sec
†Z(X)J	ζ_j
†W(X)J	ω_{n_j}, rad/sec

For example:

```
DENOMINATOR
   1/T(DET)1        .0318
   1/T(DET)2        2.20
   Z(DET)1          .0609
   W(DET)1          1.13

NUMERATORS
N(B  /DR )
   A(B   )          .0295
   1/T(B   )1       -.0494
   1/T(B   )2       2.05
   1/T(B   )3       42.3
```

Translates to: $$\frac{\beta}{\delta_r} = \frac{.0295(s - .0494)(s + 2.05)(s + 42.3)}{(s + .0318)(s + 2.20)(s^2 + 2 \times .0609 \times 1.13s + 1.13^2s^2)}$$

---

*The transfer function x/y is written as:

$$x/y = \frac{N_y^x}{\Delta} = \frac{A_x(s^m + s^{m-1} + \dots s^0)}{(s^n + s^{n-1} + \dots s^0)}$$

†Any roots enclosed in parentheses imply the opposite order of what is specified, e.g., Z(DET)1 = (0.00132) ⇒ 1/T(DET)1 = 0.00132

e. LONGITUDINAL HANDLING QUALITY PARAMETERS

COMPUTER PRINT OUT	STANDARD NOTATION, DEFINITION	EQUATION
D(G)/D(U) (DEG/KT)	$\partial\gamma/\partial u$, degrees/knot	$(1.689)(57.3)\dfrac{\left[N_\delta^\theta(s) + \dfrac{W_0}{V_{T_0}^2} N_\delta^u(s) - \dfrac{U_0}{V_{T_0}^2} N_\delta^w(s)\right]}{\dfrac{U_0}{V_{T_0}} N_\delta^u(s) + \dfrac{W_0}{V_{T_0}} N_\delta^w(s)}$, for $s = 0$
NZA (G/RAD)	N_{z_α}, g/rad	*$\dfrac{-U_0}{g}\dfrac{\hat{N}_\delta^{a_z}(s)}{\hat{N}_\delta^w(s)}$, for $s = 0$
DE/G (DEG/G)	δ_e/g, degrees/g	$57.3\left(\dfrac{1}{g}\dfrac{\hat{N}_\delta^{a_z}(s)}{\hat{\Delta}(s)}\right)^{-1}$, for $s = 0$
CAP (RAD/SEC/SEC/G)	Control anticipation parameter, rad/sec^2/g	$-\left(\dfrac{s^2\hat{N}_\delta^\theta(s)}{\hat{\Delta}(s)}\Big\vert_{s\to\infty}\right)\Big/\left(\dfrac{1}{g}\dfrac{\hat{N}_\delta^{a_z}}{\hat{\Delta}}\Big\vert_{s=0}\right)$
PHUGOID(2) (TUCK(2))	The phugoid time to double amplitude, seconds	$\dfrac{\ln 2}{\lvert\zeta_{ph}\omega_{n_{ph}}\rvert}$, for $\zeta_{ph} < 0$
1/C(1/10)	Short period inverse cycles to 1/10 amplitude	$\dfrac{2\pi}{\ln 10}\sqrt{\dfrac{\zeta_{sp}^2}{1 - \zeta_{sp}}}$ for $0 \le \zeta_{sp} < 1$
FST/KT (LB/KT)	Stick force per knot, pounds/knot	$1.689\left[\dfrac{u}{F_{st}}(s)\right]^{-1}$ for $s = 0$
FST/G (LB/G)	Stick force per g, pounds per g	$\left[\dfrac{1}{g}\dfrac{\hat{N}_{F_{st}}^{a_z}}{\hat{\Delta}}\right]^{-1}$ for $s = 0$
--	The parameter has no meaning or is not defined at this flight condition	

*The hat ($\hat{N}$) notation implies constant speed ($u = \theta_0 = 0$).

f. LATERAL-DIRECTIONAL HANDLING QUALITY PARAMETERS

COMPUTER PRINT OUT	STANDARD NOTATION, DEFINITION	EQUATION
DR PERIOD (SEC)	Dutch roll period, seconds	$2\pi/\omega_{n_d}\sqrt{1-\zeta_d^2}$
1/C(1/2)	Dutch roll inverse cycles to 1/2 amplitude	$\frac{2\pi}{\ln 2}\sqrt{\frac{\zeta_d^2}{1-\zeta_d^2}}$, for $\zeta_d \geq 0$
SPIRAL (2) (SEC)	Spiral time to double amplitude, seconds	$T_s \ln 2$, for $1/T_s \leq 0$
P(I)	Roll rate at peak I for a unit step input of δ_a	
P(OSC)/P(AV)	A measure of the oscillatory to the average roll rate	$\frac{p_1 + p_3 - 2p_2}{p_1 + p_3 + 2p_2}$, for $\zeta_d \leq 0.2$ $\frac{p_1 - p_2}{p_1 + p_2}$, for $\zeta_d > 0.2$
W(PHI)/W(D)	Ratio of the roll frequency to the dutch roll frequency	$\omega_{n_\varphi}/\omega_{n_d}$
DEL-B-MAX	$\Delta\beta_m$: Maximum sideslip excursion at the c.g., occurring within two seconds or one half-period of the dutch roll, whichever is greater for a step aileron-control command	
PHI to BETA, PHASE	$\measuredangle \varphi/\beta$ at $s = (\zeta; \omega_n)_d$, degrees	
PHI TO BETA	$\lvert\varphi/\beta\rvert$ at $s = (\zeta; \omega_n)_d$, rad/rad	
PHI TO VE	*$\lvert\varphi/v_e\rvert$ at $s = (\zeta; \omega_n)_d$, deg/fps	

*$v_e = (\beta)(V_{EAS})$, $V_{EAS} = \sqrt{\frac{2q}{\rho_o}}$

4. NONDIMENSIONAL DERIVATIVE DEFINITIONS

a) Longitudinal Body Axis

$C_N = \frac{N}{\bar{q}\,S}$, positive up

$C_X = -\frac{X}{\bar{q}\,S}$, positive aft

$C_{N_\alpha} = \partial C_N/\partial\alpha$

$C_{N_{\dot\alpha}} = \frac{2V_{T_0}}{c}\,\partial C_N/\partial\dot\alpha$

$C_{N_M} = \partial C_N/\partial M$

$C_{N_\delta} = \partial C_N/\partial\delta$

$C_{X_\alpha} = \partial C_X/\partial\alpha$

$C_{X_M} = \partial C_X/\partial M$

$C_{X_\delta} = \partial C_X/\partial\delta$

$C_M = \frac{M}{\bar{q}\,Sc}$

$C_{M_\alpha} = \partial C_M/\partial\alpha$

$C_{M_{\dot\alpha}} = \frac{2V_{T_0}}{c}\,\partial C_M/\partial\dot\alpha$

$C_{M_M} = \partial C_M/M$

$C_{M_q} = \frac{2V_{T_0}}{c}\,\partial C_M/\partial q$

b) Longitudinal Stability Axis

$C_L = \frac{L}{\bar{q}\,S}$, positive up

$C_D = \frac{D}{\bar{q}\,S}$, positive aft

$C_{L_\alpha} = \partial C_L/\partial\alpha$

$C_{L_{\dot\alpha}} = \frac{2V_{T_0}}{C}\,\partial C_L/\partial\dot\alpha$

$C_{L_M} = \partial C_L/\partial M$

$C_{L_\delta} = \partial C_L/\partial\delta$

$C_{D_\alpha} = \partial C_D/\partial\alpha$

$C_{D_M} = \partial C_D/\partial M$

$C_{D_\delta} = \partial C_L/\partial\delta$

Pitching moment derivatives are identical to those for body axis

c) Lateral Body and Stability Axis

Though physically and numerically different,* see Appendix B, the same symbols are used for body axis and stability axis lateral rolling and yawing moment derivatives. The sideforce derivatives (C_y, etc.) ar physically and numerically the same in both axis systems. When the rolling or yawing moment derivatives are given in this report the axis system is specified. When using the following all quantities should be for the same axis system.

$$C_y = \frac{Y}{\bar{q}S} \qquad C_l = \frac{L}{\bar{q}Sb} \qquad C_n = \frac{N}{\bar{q}Sb}$$

$$C_{y_\beta} = \partial C_y/\partial\beta \qquad C_{l_\beta} = \partial C_l/\partial\beta \qquad C_{n_\beta} = \partial C_n/\partial\beta$$

$$C_{y_\delta} = \partial C_y/\partial\delta \qquad C_{l_p} = \frac{2V_{T_o}}{b}\,\partial C_l/\partial p \qquad C_{n_p} = \frac{2V_{T_o}}{b}\,\partial C_N/\partial p$$

$$C_{l_r} = \frac{2V_{T_o}}{b}\,\partial C_l/\partial r \qquad C_{n_r} = \frac{2V_{T_o}}{b}\,\partial C_N/\partial r$$

$$C_{l_\delta} = \partial C_l/\partial\delta \qquad C_{n_\delta} = \partial C_n/\partial\delta$$

*The exception is the zero trim angle of attack condition.

5. DIMENSIONAL STABILITY DERIVATIVE DEFINITIONS

The same symbols are used for body- and stability-axis dimensional derivatives. Care should be exercised so that a consistent set of quantities are used.

a) Longitudinal Body Axis

$$X_u^* = X_u + T_u \cos\xi_o \qquad 1/\text{sec}$$

$$X_u = \frac{\rho S U_o}{m}\left(-\frac{M}{2} C_{X_M} - C_X + \frac{W_o}{2U_o} C_{X_\alpha}\right) \qquad 1/\text{sec}$$

$$X_w = \frac{\rho S U_o}{2m}\left[-C_{X_\alpha} - 2\frac{W_o}{U_o}\left(C_X + \frac{M}{2} C_{X_M}\right)\right] \qquad 1/\text{sec}$$

$$X_{\delta_e} = -\frac{\rho S V_{T_o}^2}{2m} C_{X_{\delta_e}} \qquad \frac{\text{ft}}{\text{sec}^2\text{rad}}$$

$$Z_u^* = Z_u - T_u \sin\xi_o \qquad 1/\text{sec}$$

$$Z_u = \frac{\rho S U_o}{m}\left(-\frac{M}{2} C_{N_M} - C_N + \frac{W_o}{2U_o} C_{N_\alpha}\right) \qquad 1/\text{sec}$$

$$Z_w = \frac{\rho S U_o}{2m}\left[-C_{N_\alpha} - 2\frac{W_o}{U_o}\left(C_N + \frac{M}{2} C_{N_M}\right)\right] \qquad 1/\text{sec}$$

$$Z_{\dot w} = -\frac{\rho S c}{4m}\frac{U_o}{V_{T_o}} C_{N_{\dot\alpha}}$$

$$Z_{\delta_e} = -\frac{\rho S V_{T_o}^2}{2m} C_{N_{\delta_e}} \qquad \frac{\text{ft}}{\text{sec}^2\text{rad}}$$

$$M_u^* = M_u + \frac{\Delta_{th}}{I_y} T_u \qquad \frac{1}{\text{sec-ft}}$$

M_u	$= \dfrac{\rho S c U_o}{I_y}\left[\dfrac{M}{2} C_{m_M} + C_m - \dfrac{W_o}{2U_o} C_{m_\alpha}\right]$	$\dfrac{1}{\text{sec-ft}}$
M_w	$= \dfrac{\rho S c U_o}{2I_y}\left[C_{m_\alpha} + \dfrac{2W_o}{U_o}\left(C_m + \dfrac{M}{2} C_{m_M}\right)\right]$	$\dfrac{1}{\text{sec-ft}}$
$M_{\dot{w}}$	$= \dfrac{\rho S c^2}{4I_y} \dfrac{U_o}{V_{T_o}} C_{m_{\dot{\alpha}}}$	$\dfrac{1}{\text{sec-ft}}$
M_α	$= U_o M_w$	$1/\text{sec}^2$
$M_{\dot{\alpha}}$	$= U_o M_{\dot{w}}$	$1/\text{sec}$
M_q	$= \dfrac{\rho S c^2 V_{T_o}}{4I_y} C_{m_q}$	$1/\text{sec}$
M_{δ_e}	$= \dfrac{\rho S c V_{T_o}^2}{2I_y} C_{m_{\delta_e}}$	$1/\text{sec}^2$
T_u	$= \dfrac{1}{am} \partial T/\partial M$	$1/\text{sec}$

b) **Lateral Body Axis**

Y_v	$= (\rho S V_{T_o}/2m) C_{y_\beta}$	$1/\text{sec}$
Y_β	$= V_{T_o} Y_v$	ft/sec^2
Y_{δ_a}	$= (\rho S V_{T_o}^2/2m) C_{y_{\delta_a}}$	ft/sec^2
Y_{δ_r}	$= (\rho S V_{T_o}^2/2m) C_{y_{\delta_r}}$	ft/sec^2
$Y_{\delta_r^*}$	$= (\rho S V_{T_o}/2m) C_{y_{\delta_r}}$	$1/\text{sec}$
L_β	$= (\rho S V_{T_o}^2 b/2I_x) C_{l_\beta}$	$1/\text{sec}^2$
L_p	$= (\rho S V_{T_o} b^2/4I_x) C_{l_p}$	$1/\text{sec}$
L_r	$= (\rho S V_{T_o} b^2/4I_x) C_{l_r}$	$1/\text{sec}$

$$L_{\delta_a} = (\rho S V_{T_o}^2 b/2I_x) C_{l_{\delta_a}} \qquad 1/\sec^2$$

$$L_{\delta_r} = (\rho S V_{T_o}^2 b/2I_x) C_{l_{\delta_r}} \qquad 1/\sec^2$$

$$Y_{\delta_a}^* = (\rho S V_{T_o}/2m) C_{y_{\delta_a}} \qquad 1/\sec$$

$$N_\beta = (\rho S V_{T_o}^2 b/2I_z) C_{n_\beta} \qquad 1/\sec^2$$

$$N_p = (\rho S V_{T_o} b^2/4I_z) C_{n_p} \qquad 1/\sec$$

$$N_r = (\rho S V_{T_o} b^2/4I_z) C_{n_r} \qquad 1/\sec$$

$$N_{\delta_a} = (\rho S V_{T_o}^2 b/2I_z) C_{n_{\delta_a}} \qquad 1/\sec^2$$

$$N_{\delta_r} = (\rho S V_{T_o}^2 b/2I_z) C_{n_{\delta_r}} \qquad 1/\sec^2$$

$$L_\beta' = (L_\beta + I_{xz} N_\beta/I_x) G \qquad 1/\sec^2$$

$$L_p' = (L_p + I_{xz} N_p/I_x) G \qquad 1/\sec$$

$$L_r' = (L_r + I_{xz} N_r/I_x) G \qquad 1/\sec$$

$$L_{\delta_r}' = (L_{\delta_r} + I_{xz} N_{\delta_r}/I_x) G \qquad 1/\sec^2$$

$$L_{\delta_a}' = (L_{\delta_a} + I_{xz} N_{\delta_a}/I_x) G \qquad 1/\sec^2$$

$$N_\beta' = (N_\beta + I_{xz} L_\beta/I_z) G \qquad 1/\sec^2$$

$$N_p' = (N_p + I_{xz} L_p/I_z) G \qquad 1/\sec$$

$$N_r' = (N_r + I_{xz} L_r/I_z) G \qquad 1/\sec$$

$$N_{\delta_r}' = (N_{\delta_r} + I_{xz} L_{\delta_r}/I_z) G \qquad 1/\sec^2$$

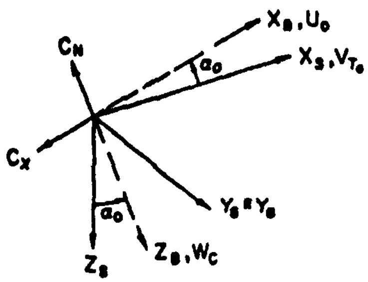
$$N_{\delta_a}' = (N_{\delta_a} + I_{xz} L_{\delta_a}/I_z) G \qquad 1/\sec^2$$

$$G = \frac{1}{1 - \frac{I_{xz}^2}{I_x I_z}}$$

APPENDIX B

TRANSFORMATION OF STABILITY AXIS DERIVATIVES TO BODY AXIS

a. NON-DIMENSIONAL STABILITY AXIS TO BODY AXIS



$U_o = V_{T_o} \cos \alpha_o$

$W_o = V_{T_o} \sin \alpha_o$

LONGITUDINAL

Body Axis

$C_N = C_L \cos \alpha_o + C_D \sin \alpha_o$

$C_X = C_D \cos \alpha_o - C_L \sin \alpha_o$

$C_{N_\alpha} = C_{L_\alpha} \cos \alpha_o - C_L \sin \alpha_o + C_{D_\alpha} \sin \alpha_o + C_D \cos \alpha_o$

$C_{N_{\dot\alpha}} = C_{L_{\dot\alpha}} \cos \alpha_o$

$C_{N_q} = C_{L_q} \cos \alpha_o$

$C_{N_M} = C_{L_M} \cos \alpha_o + C_{D_M} \sin \alpha_o$

$C_{N_\delta} = C_{L_\delta} \cos \alpha_o + C_{D_\delta} \sin \alpha_o$

$C_{X_\alpha} = C_{D_\alpha} \cos \alpha_o - C_D \sin \alpha_o - C_{L_\alpha} \sin \alpha_o - C_L \cos \alpha_o$

$C_{X_{\dot\alpha}} = -C_{L_{\dot\alpha}} \sin \alpha_o$

$C_{X_q} = -C_{L_q} \sin \alpha_o$

$C_{X_M} = C_{D_M} \cos \alpha_o - C_{L_M} \sin \alpha_o$

$C_{X_\delta} = C_{D_\delta} \cos \alpha_o - C_{L_\delta} \sin \alpha_o$

$C_m, C_{m_{\dot\alpha}}, C_{m_\alpha}, C_{m_q}, C_{m_M}, C_{m_\delta}$ - UNCHANGED

LATERAL

Body Axis

$(C_{l_\beta})_B = C_{l_\beta} \cos \alpha_o - C_{n_\beta} \sin \alpha_o$

$(C_{l_p})_B = C_{l_p} \cos^2\alpha_o - (C_{l_r} + C_{n_p}) \sin \alpha_o \cos \alpha_o + C_{n_r} \sin^2\alpha_o$

$(C_{l_r})_B = C_{l_r} \cos^2\alpha_o - (C_{n_r} - C_{l_p}) \sin \alpha_o \cos \alpha_o - C_{n_p} \sin^2\alpha_o$

$(C_{l_\delta})_B = C_{l_\delta} \cos \alpha_o - C_{n_\delta} \sin \alpha_o$

$(C_{n_\beta})_B = C_{n_\beta} \cos \alpha_o + C_{l_\beta} \sin \alpha_o$

$(C_{n_p})_B = C_{n_p} \cos^2\alpha_o - (C_{n_r} - C_{l_p}) \sin \alpha_o \cos \alpha_o - C_{l_r} \sin^2\alpha_o$

$(C_{n_r})_B = C_{n_r} \cos^2\alpha_o + (C_{l_r} - C_{n_p}) \sin \alpha_o \cos \alpha_o + C_{l_p} \sin^2\alpha_o$

$(C_{n_\delta})_B = C_{n_\delta} \cos \alpha_o + C_{l_\delta} \sin \alpha_o$

$C_{y_\beta}, C_{y_{\delta_r}}, C_{y_{\delta_a}}$ - UNCHANGED

b. TRANSFORMATION OF DIMENSIONAL DERIVATIVES FROM STABILITY AXIS TO BODY AXIS

Longitudinal

$$(X_u)_b = X_u \cos^2 \alpha_o - (X_w + Z_u) \sin \alpha_o \cos \alpha_o + Z_w \sin^2 \alpha$$

$$(X_{\dot u})_b = Z_{\dot w} \sin^2 \alpha_o$$

$$(X_w)_b = X_w \cos^2 \alpha_o + (X_u - Z_w) \sin \alpha_o \cos \alpha_o - Z_u \sin^2 \alpha_o$$

$$(X_{\dot w})_b = X_{\dot w} \cos^2 \alpha_o - Z_{\dot w} \sin \alpha_o \cos \alpha_o$$

$$(X_{q;\delta})_b = X_{q;\delta} \cos \alpha_o - Z_{q;\delta} \sin \alpha_o$$

$$(Z_u)_b = Z_u \cos^2 \alpha_o - (Z_w - X_u) \sin \alpha_o \cos \alpha_o - X_w \sin^2 \alpha_o$$

$$(Z_{\dot u})_b = -Z_{\dot w} \sin \alpha_o \cos \alpha_o$$

$$(Z_w)_b = Z_w \cos^2 \alpha_o + (Z_u + X_w) \sin \alpha_o \cos \alpha_o + X_u \sin^2 \alpha_o$$

$$(Z_{\dot w})_b = Z_{\dot w} \cos^2 \alpha_o + X_{\dot w} \sin \alpha_o \cos \alpha_o$$

$$(Z_{q;\delta})_b = Z_{q;\delta} \cos \alpha_o + X_{q;\delta} \sin \alpha_o$$

$$(M_u)_b = M_w \cos \alpha_o - M_u \sin \alpha_o$$

$$(M_{\dot u})_b = -M_{\dot w} \sin \alpha_o$$

$$(M_w)_b = M_w \cos \alpha_o + M_u \sin \alpha_o$$

$$(M_{\dot w})_b = M_{\dot w} \cos \alpha_o$$

$$(M_{q;\delta})_b = M_{q;\delta}$$

$$(I_y)_b = I_y$$

Lateral-Directional

$$(Y_{v;\delta})_b = Y_{v;\delta}$$

$$(Y_{\dot{v}})_b = Y_{\dot{v}}$$

$$(Y_p)_b = Y_p \cos \alpha_o - Y_r \sin \alpha_o$$

$$(Y_r)_b = Y_r \cos \alpha_o + Y_p \sin \alpha_o$$

$$(L'_{v;\delta})_b = L'_{v;\delta} \cos \alpha_o - N'_{v;\delta} \sin \alpha_o$$

$$(L'_{\dot{v}})_b = L'_{\dot{v}} \cos \alpha_o - N'_{\dot{v}} \sin \alpha_o$$

$$(L'_p)_b = L'_p \cos^2 \alpha_o - (L'_r + N'_p) \sin \alpha_o \cos \alpha_o + N'_r \sin^2 \alpha_o$$

$$(L'_r)_b = L'_r \cos^2 \alpha_o - (N'_r - L'_p) \sin \alpha_o \cos \alpha_o - N'_p \sin^2 \alpha_o$$

$$(N'_{v;\delta})_b = N'_{v;\delta} \cos \alpha_o + L'_{v;\delta} \sin \alpha_o$$

$$(N'_{\dot{v}})_b = N'_{\dot{v}} \cos \alpha_o + L'_{\dot{v}} \sin \alpha_o$$

$$(N'_p)_b = N'_p \cos^2 \alpha_o - (N'_r - L'_p) \sin \alpha_o \cos \alpha_o - L'_r \sin^2 \alpha_o$$

$$(N'_r)_b = N'_r \cos^2 \alpha_o + (L'_r + N'_p) \sin \alpha_o \cos \alpha_o + L'_p \sin^2 \alpha_o$$

$$(I_x)_b = I_x \cos^2 \alpha_o + 2I_{xz} \sin \alpha_o \cos \alpha_o + I_z \sin^2 \alpha_o$$

$$(I_z)_b = I_z \cos^2 \alpha_o - 2I_{xz} \sin \alpha_o \cos \alpha_o + I_x \sin^2 \alpha_o$$

$$(I_{xz})_b = (I_z - I_x) \sin \alpha_o \cos \alpha_o + I_{xz}(\cos^2 \alpha_o - \sin^2 \alpha_o)$$

APPENDIX C

EQUATIONS OF MOTION, TRANSFER FUNCTIONS, AND COUPLING NUMERATORS

1. Longitudinal

a. Equations

$$\begin{bmatrix} (1-X_{\dot{u}})s-X_u^* & -X_{\dot{w}}s-X_w & (-X_q+W_o)s+g\cos\theta_o \\ -Z_{\dot{u}}s-Z_u^* & (1-Z_{\dot{w}})s-Z_w & (-Z_q-U_o)s+g\sin\theta_o \\ -M_{\dot{u}}s-M_u^* & -(M_{\dot{w}}s+M_w) & s^2-M_qs \end{bmatrix} \begin{bmatrix} u \\ w \\ \theta \end{bmatrix} = \begin{bmatrix} X_{\delta_e} \\ Z_{\delta_e} \\ M_{\delta_e} \end{bmatrix} \begin{bmatrix} \delta_e \end{bmatrix}$$

$$q = s\theta$$

$$\dot{h} = -w\cos\theta_o + u\sin\theta_o + (U_o\cos\theta_o + W_o\sin\theta_o)\theta$$

$$a_z = sw - U_oq + (g\sin\theta_o)\theta$$

$$a_z' = a_z - l_xs^2\theta$$

$$\dot{h}' = \dot{h} + \ell_x\cos\theta_o\,\dot{\theta}$$

b. Transfer Functions

$$\frac{\theta}{\delta_e} = \frac{N_{\delta_e}^{\theta}}{\Delta}$$

1) Denominator, $\Delta = As^4 + Bs^3 + Cs^2 + Ds + E$

$$A = (1 - Z_{\dot{w}})$$

$$B = -(M_q + X_u^*)(1 - Z_{\dot{w}}) - Z_w - M_{\dot{\alpha}}$$

$$C = M_qZ_w - M_\alpha + X_u^*[(M_q)(1 - Z_{\dot{w}}) + Z_w + M_{\dot{\alpha}}]$$
$$- X_wZ_u^* + W_o[M_{\dot{w}}Z_u^* + M_u^*(1 - Z_{\dot{w}})] + gM_{\dot{w}}\sin\theta_o$$

NOTE: Terms including $X_{\dot{u}}$, $Z_{\dot{u}}$, $M_{\dot{u}}$, $X_{\dot{w}}$ are neglected in polynomial expressions.

$$D = -X_u^*(M_qZ_w - M_\alpha) - M_u^*X_\alpha + M_qX_wZ_u^* + g\left[M_{\dot{w}}Z_u^* + M_u^*(1 - Z_{\dot{w}})\right]\cos\theta_o + W_o(M_wZ_u^* - M_u^*Z_w)$$
$$+\ g(M_w - M_{\dot{w}}X_u^*)\sin\theta_o$$

$$E = g(M_wZ_u^* - M_u^*Z_w)\cos\theta_o + g(M_u^*X_w - M_wX_u^*)\sin\theta_o$$

2) Numerators

$$N_\delta^\theta = A_\theta s^2 + B_\theta s + C_\theta$$

$$A_\theta = Z_\delta M_{\dot{w}} + M_\delta(1 - Z_{\dot{w}})$$

$$B_\theta = X_\delta\left[M_{\dot{w}}Z_u^* + M_u^*(1 - Z_{\dot{w}})\right] + Z_\delta(M_w - M_{\dot{w}}X_u^*) - M_\delta\left[Z_w + X_u^*(1 - Z_{\dot{w}})\right]$$

$$C_\theta = X_\delta(M_wZ_u^* - M_u^*Z_w) + Z_\delta(M_u^*X_w - M_wX_u^*) + M_\delta(Z_wX_u^* - X_wZ_u^*)$$

$$N_\delta^u = A_u s^3 + B_u s^2 + C_u s + D_u$$

$$A_u = X_\delta(1 - Z_{\dot{w}})$$

$$B_u = -X_\delta\left[M_q(1 - Z_{\dot{w}}) + Z_w + M_\alpha\right] + Z_\delta X_w - W_o\left[Z_\delta M_{\dot{w}} + M_\delta(1 - Z_{\dot{w}})\right]$$

$$C_u = X_\delta(M_qZ_w - M_\alpha) - Z_\delta(gM_{\dot{w}}\cos\theta_o + M_qX_w) + M_\delta\left[X_\alpha - (g\cos\theta_o)(1 - Z_{\dot{w}})\right]$$
$$+\ W_o(Z_wM_\delta - M_wZ_\delta) + gX_\delta M_{\dot{w}}\sin\theta_o$$

$$D_u = g(Z_wM_\delta - M_wZ_\delta)\cos\theta_o + g(X_\delta M_w - M_\delta X_w)\sin\theta_o$$

$$N_\delta^w = A_w s^3 + B_w s^2 + C_w s + D_w$$

$$A_w = Z_\delta$$

$$B_w = -Z_\delta(M_q + X_u^*) + U_oM_\delta + X_\delta Z_u^*$$

$$C_w = X_u^*(Z_\delta M_q - U_oM_\delta) + W_o(Z_\delta M_u^* - M_\delta Z_u^*) - gM_\delta\sin\theta_o + X_\delta(M_u^*U_o - Z_u^*M_q)$$

$$D_w = g(Z_\delta M_u^* - M_\delta Z_u^*)\cos\theta_o + gM_\delta X_u^*\sin\theta_o - X_\delta M_u^*g\sin\theta_o$$

$N_\delta^{\dot h} = A_{\dot h}s^3 + B_{\dot h}s^2 + C_{\dot h}s + D_{\dot h}$
$A_{\dot h} = -\cos\theta_o A_w + \sin\theta_o A_u$
$B_{\dot h} = -\cos\theta_o B_w + \sin\theta_o B_u + (U_o\cos\theta_o + W_o\sin\theta_o)A_\theta$
$C_{\dot h} = -\cos\theta_o C_w + \sin\theta_o C_u + (U_o\cos\theta_o + W_o\sin\theta_o)B_\theta$
$D_{\dot h} = -\cos\theta_o D_w + \sin\theta_o D_u + (U_o\cos\theta_o + W_o\sin\theta_o)C_\theta$

$N_\delta^{a_z'} = A_{a_z'}s^4 + B_{a_z'}s^3 + C_{a_z'}s^2 + D_{a_z'}s + E_{a_z'}$
$A_{a_z'} = A_w - l_x A_\theta$
$B_{a_z'} = B_w - l_x B_\theta - U_o A_\theta$
$C_{a_z'} = C_w - l_x C_\theta - U_o B_\theta + g\sin\theta_o A_\theta$
$D_{a_z'} = D_w - U_o C_\theta + g\sin\theta_o B_\theta$
$E_{a_z'} = +g\sin\theta_o C_\theta$

To obtain a_z, let $l_x = 0$.

2. Lateral

a. Equations

$$\begin{bmatrix} s - Y_v & -\frac{W_o s + g\cos\theta_o}{V_{T_o}} & \frac{U_o s - g\sin\theta_o}{V_{T_o}s} \\ -L_\beta' & s(s - L_p') & -L_r' \\ -N_\beta' & -N_p' s & s - N_r' \end{bmatrix} \begin{bmatrix} \beta \\ \frac{p}{s} \\ r \end{bmatrix} = \begin{bmatrix} Y_{\delta_a}^* & Y_{\delta_r}^* \\ L_{\delta_a}' & L_{\delta_r}' \\ N_{\delta_a}' & N_{\delta_r}' \end{bmatrix} \begin{bmatrix} \delta_a \\ \delta_r \end{bmatrix}$$

$$v = V_{T_o}\beta \qquad a_y = sv + U_o r - W_o p - g(\cos\theta_o)\varphi$$

$$\varphi = \frac{p}{s} + \frac{r}{s}\tan\theta_o \qquad a_y' = a_y + l_{x_{lat}} sr - l_z sp$$

$$\psi = \frac{1}{\cos\theta_o}\frac{r}{s}$$

b. Transfer Functions

$$\frac{\varphi}{\delta_a} = \frac{N^{\varphi}_{\delta_a}}{\Delta_{lat}} \quad ; \quad \frac{r}{\delta_r} = \frac{N^{r}_{\delta_r}}{\Delta_{lat}} \quad ; \quad \text{etc.}$$

1) Denominator, $\Delta_{lat} = as^4 + bs^3 + cs^2 + ds + e$

$$a = 1$$

$$b = -(Y_v + L'_p + N'_r)$$

$$c = \frac{U_o}{VT_o} N'_\beta + L'_p(Y_v + N'_r) - N'_p L'_r + Y_v N'_r - \frac{W_o L'_\beta}{VT_o}$$

$$d = \frac{U_o}{VT_o}(N'_p L'_\beta - L'_p N'_\beta) + Y_v(N'_p L'_r - L'_p N'_r) - \frac{g}{VT_o}(L'_\beta \cos\theta_o + N'_\beta \sin\theta_o) + \frac{W_o}{VT_o}(L'_\beta N'_r - N'_\beta L'_r)$$

$$e = \frac{g}{VT_o}\left[(L'_\beta N'_r - N'_\beta L'_r)\cos\theta_o - (N'_p L'_\beta - L'_p N'_\beta)\sin\theta_o\right]$$

2) δ (δ_a or δ_r) Numerators

$$N^{\beta}_{\delta} = A_\beta s^3 + B_\beta s^2 + C_\beta s + D_\beta$$

$$A_\beta = Y^*_\delta$$

$$B_\beta = -Y^*_\delta[L'_p + N'_r] - N'_\delta \frac{U_o}{VT_o} + \frac{W_o}{VT_o} L'_\delta$$

$$C_\beta = Y^*_\delta(L'_p N'_r - N'_p L'_r) + L'_\delta \frac{g}{VT_o}\cos\theta_o + (N'_\delta L'_p - L'_\delta N'_p)\frac{U_o}{VT_o} + \frac{W_o}{VT_o}(N'_\delta L'_r - L'_\delta N'_r) + N'_\delta \frac{g}{VT_o}\sin\theta_o$$

$$D_\beta = \frac{g}{VT_o}(N'_\delta L'_r - L'_\delta N'_r)\cos\theta_o + \frac{g}{VT_o}(N'_p L'_\delta - N'_\delta L'_p)\sin\theta_o$$

$$N_\delta^p = A_p s^3 + B_p s^2 + C_p s + D_p$$

$$A_p = L'_\delta$$

$$B_p = Y^*_\delta L'_\beta - L'_\delta(N'_r + Y_v) + N'_\delta L'_r$$

$$C_p = Y^*_\delta(L'_r N'_\beta - L'_\beta N'_r) + L'_\delta Y_v N'_r - N'_\delta Y_v L'_r + (L'_\delta N'_\beta - N'_\delta L'_\beta)\frac{U_o}{VT_o}$$

$$D_p = -\frac{g}{VT_o}(L'_\delta N'_\beta - N'_\delta L'_\beta)\sin\theta_o$$

$$N_\delta^r = A_r s^3 + B_r s^2 + C_r s + D_r$$

$$A_r = N'_\delta$$

$$B_r = Y^*_\delta N'_\beta + L'_\delta N'_p - N'_\delta(Y_v + L'_p)$$

$$C_r = Y^*_\delta(L'_\beta N'_p - N'_\beta L'_p) - L'_\delta Y_v N'_p + N'_\delta Y_v L'_p + \frac{W_o}{VT_o}(L'_\delta N'_\beta - N'_\delta L'_\beta)$$

$$D_r = \frac{g}{VT_o}(L'_\delta N'_\beta - N'_\delta L'_\beta)\cos\theta_o$$

$$N_\delta^\Phi = A_\Phi s^2 + B_\Phi s + C$$

$$A_\Phi = A_p + A_r \tan\theta_o$$

$$B_\Phi = B_p + B_r \tan\theta_o$$

$$C_\Phi = C_p + C_r \tan\theta_o$$

$$N_{\delta}^{a'_y} = A'_{a_y}s^4 + B'_{a_y}s^3 + C'_{a_y}s^2 + D'_{a_y}s + E'_{a_y}$$

$$A'_{a_y} = V_{T_o}A_{\beta} + l_{x_{lat}}A_r - l_z A_p$$

$$B'_{a_y} = V_{T_o}B_{\beta} + U_o A_r - W_o A_p + l_{x_{lat}}B_r - l_z B_p$$

$$C'_{a_y} = V_{T_o}C_{\beta} + U_o B_r - W_o B_p - g \cos \theta_o A_{\phi} + l_{x_{lat}}C_r - l_z C_p$$

$$D'_{a_y} = V_{T_o}D_{\beta} + U_o C_r - W_o C_p - g \cos \theta_o B_{\phi} + l_{x_{lat}}D_r - l_z D_p$$

$$E'_{a_y} = U_o D_r - W_o D_p - g \cos \theta_o C_{\phi}$$

To obtain a_y, let $l_{x_{lat}} = l_z = 0$.